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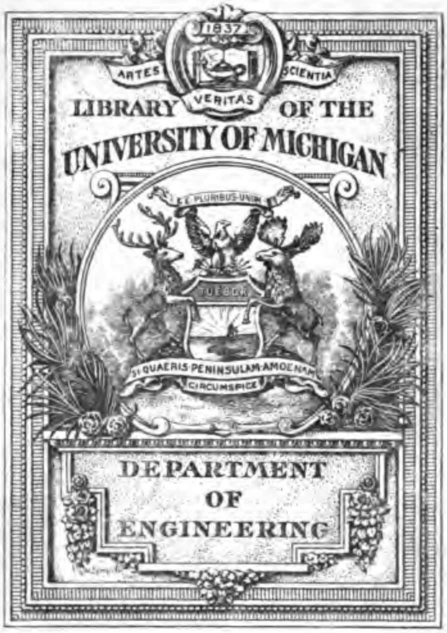

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AVIATION AND ITS FUTURE

INSTRUCTION PAPER

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AVIATION AND ITS FUTURE

DIRIGIBLE VS. AEROPLANE

While interest, to a great extent, is monopolized by the achievements of the aeroplane, opinion is still more or less divided as to the merits of the two methods of navigating the air—the lighter-than-air (the dirigible) or the heavier-than-air (the aeroplane). Though greatly in the minority, those who contend for the advantages of the dirigible are none the less convinced that, in the final analysis, it will be the airship rather than the flying machine which will reign supreme. From this standpoint, the aeroplane is regarded as a mere scientific toy of rather doubtful utility. The advocates of the flying machine, on the other hand, look upon the dirigible as a huge, unwieldy, and prohibitively costly construction, the futility of which as a successful means of navigating the air will be fully realized by reason of the development of the aeroplane within the next few years. Between these wholly irreconcilable opinions, there is a middle ground taken by those who regard both as being of value in their particular spheres, and who think further that both will endure and develop contemporaneously. By briefly summarizing the advantages and disadvantages of each, the reader will be given an opportunity to judge for himself.

Dirigible. *Advantages.* One of the chief advantages claimed for dirigibles is their ability to take aloft comparatively heavy loads—weights far beyond the capacity of the largest aeroplanes so far constructed. This great carrying capacity permits of transporting large quantities of supplies and fuel and a large crew, with the added advantage of permitting the latter a certain range of movement about the airship while it is in flight—the aeroplanist or his passenger naturally can not stir from their seats. But of greater value than this—particularly for military purposes, to which the dirigible is almost wholly adapted at present—is its ability to remain motionless over the field of action in a calm, or by using its engines to coun-

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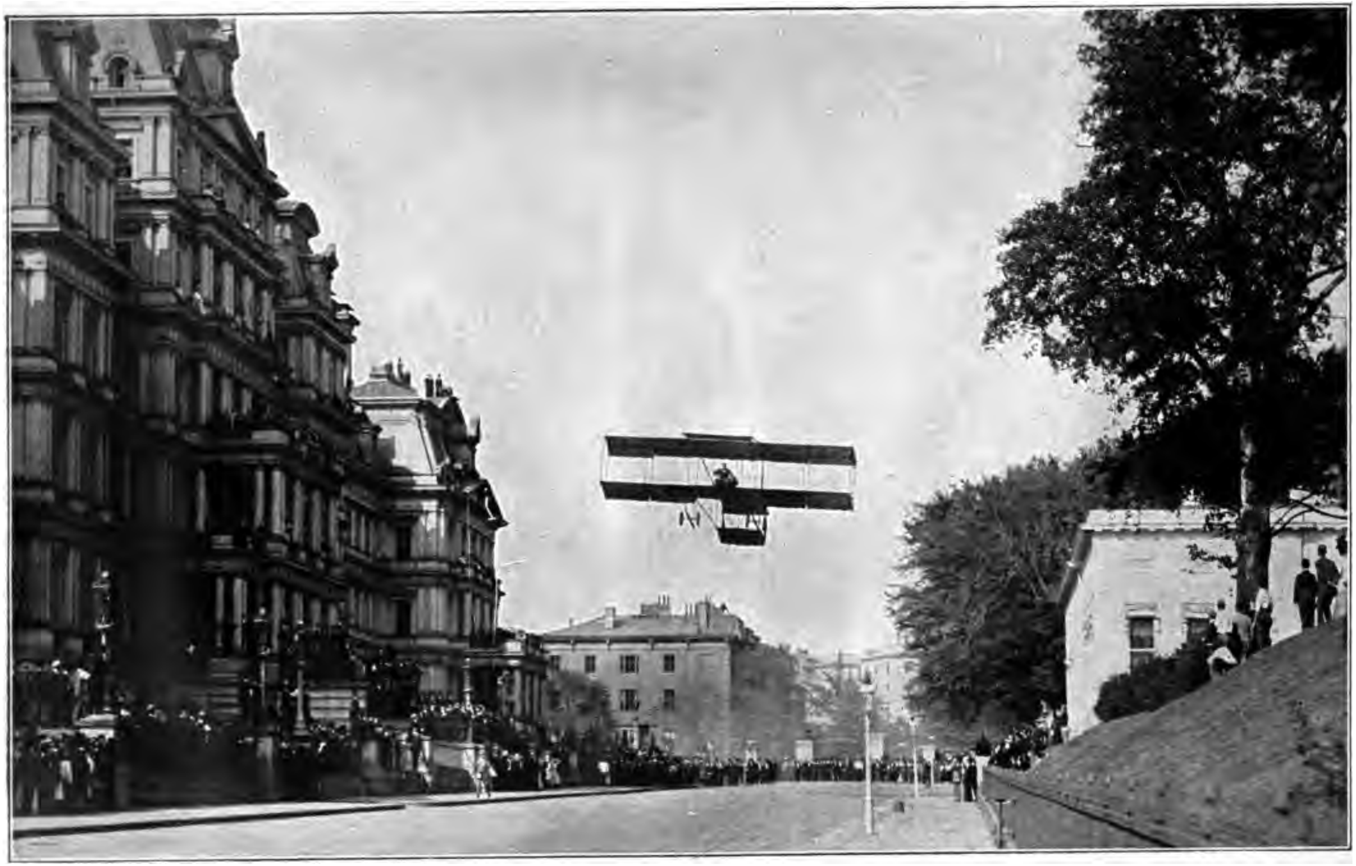

Fig. 1. Claude Grahame White Landing in the Streets of Washington, D. C. An Example of an Aeroplane's Ability to Land or Ascend under Almost Any Conditions

teract a head wind which is within its capacity to resist. Moreover, it is capable of remaining aloft and of traveling with the wind even after its fuel supply is exhausted, and in fair weather it can keep to the air for a much longer period than the aeroplane.

Disadvantages. In the first place, the initial cost of building a dirigible of sufficient size to be of any practical use is so great as to limit its utilization largely to military operations, though a number of dirigibles are being built in Germany by commercial companies for passenger carrying. Few but national governments can afford to build dirigibles. Wellman's ill-fated America, which was small as compared with the military dirigibles of the European governments, cost something like $100,000 to build and equip. Its maintenance is even more costly. The temporary shed to house the America cost $10,000 to erect and $5,000 was spent in inflating the airship once. To propel it, using full power, about 200 gallons of gasoline a day was necessary, with a proportionately large supply of oil. As its speed was low, there would be frequent occasions when the engines would have to be run at their full capacity, simply to prevent it from being carried away by the wind, while there would also be a number of days in the year when it could not safely be taken out of the shed.

To erect a permanent building to shelter one of the large European military dirigibles involves an outlay sufficient to pay for a whole fleet of aeroplanes, and the huge gas bag is never safe outside of its home. While an aeroplane can land on a city street and rise again, Fig. 1, nothing short of a twenty-acre field provides a safe landing place for a dirigible, and the operation is a delicate one even under the most favorable conditions, so much so, that the shed to house the various Zeppelin airships was anchored at first on Lake Constance in order that the dirigible always might enter it against the wind. In view of the great expense involved in providing accommodation for it, the airship is usually compelled to operate from a limited number of fixed bases, to one of which it must return. In case a high wind should spring up when it is aloft, it is equally dangerous to stay in the air or to attempt to land, and it may frequently happen that the force of the wind is so great that the airship can not reach its base at all, or it is blown away from its landing place before the numerous attendants necessary can get it under shelter. This last has happened to French military airships on two occasions, while the Zeppelin dirigibles that have come to grief through being blown to pieces against the ground form a striking illustration of one of the chief dangers to which the tremendously unwieldy apparatus has been subject, but which is now greatly reduced by improved methods of handling.

Aloft, it is surrounded by perils, both from within and without. The close proximity of such a huge quantity of highly inflammable gas to the gasoline engines or other sources of fire renders its operation risky, to say the least, while it is equally exposed to fire or explosion through being out in an electrical storm, it being the general consensus of opinion that lightning, or an electrical discharge caused by the high difference of potential between the atmosphere and the gas bag and metal parts of the airship, caused the explosion which ended the lives of Oscar Erbsloh and his five companions in one of the German military airships in the summer of 1910. As explained under "Wireless on Aeroplane and Airship," it is not necessary that the airship itself should be actually struck by lightning to bring about this discharge, although it offers a powerful attraction; its mere presence at a height where the atmosphere is heavily charged, being sufficient to create electrical discharges capable of setting fire to the gas or to the envelope.

Mention has already been made of the fact that to be of any use, the dirigible must be planned on an enormous scale, with a correspondingly disproportionate increase in the amount of gas required to inflate it and the power needed to drive it. Consequently, it has been found impossible to attain speeds in excess of 43 miles an hour, and only one airship at present in use abroad is capable of going that fast. Even with the most impermeable fabrics that can be manufactured there is more or less leakage of gas, but more serious than this by far is the loss attendant upon ascending and descending. Skillful and rapid manipulation is frequently necessary to prevent rising suddenly to great heights through temperature changes, which occasions the loss of considerable hydrogen in order to return to earth again, while cloudy weather and particularly the sudden advent of rain brings about an alarming contraction in the envelope. Reference to Wellman's experiences with the America will reveal how precarious an undertaking the keeping an airship aloft over night is, the loss of lifting power through the drop in the temperature being so great as to seriously imperil its safety. Add to this the necessity of returning to its base of operation in order to be safely housed against the wind when on the ground, and it will be apparent that the dirigible is very much of a fairweather craft, though the German army dirigibles are said to be used frequently for night trips.

Large Radius of Action. To offset this formidable list of weaknesses and disadvantages, it may be pointed out that the airship has accomplished some wonderful trips, seemingly all the more wonderful because at the time of their execution there were no other performances to compare them with. But upon referring to the circumstances under which they have been carried out, it will be found that they were usually under the most favorable conditions. The weather was favorable, the wind never in excess of 35 miles an hour, and the entire trip was of necessity completed during daylight, usually between dawn and 8 P.M., when the temperature range is not so great as seriously to affect the lifting capacity. While capable of carrying aloft a greater number than can as yet be approached by the aeroplane, it is likewise necessary to carry a much greater crew, so that the actual passenger-carrying capacity is much less than that of the aeroplane in proportion to size. Whether the latter has, as its sole freight, the aviator himself, or carries eight passengers, as in the case of the Bleriot "bus," the entire control is centered in one man. However, the dirigible has the inestimable advantage of providing direct access to the motors, so that they can be restarted, and the further advantage of being able to stop its motors and still remain aloft.

Aeroplane. *Cost.* In summarizing the advantages and disadvantages of the aeroplane in a similar manner, the first consideration is naturally that of *cost*—both initial and subsequent. Taking the cost of a good two-man machine as $5,000, the price at which the Wright biplane lists in this country, it will be seen that 100 of these machines can be placed in the field for the price of but a single Zeppelin dirigible, which is said to cost $500,000. The expense of the initial inflation of such an airship represents the equivalent of another aeroplane, while its bill for fuel would keep a great many of them in the air, and the cost of a shed for housing it would mean probably ten more, as a huge permanent building of the size required involves close to an outlay of $50,000. On the question of expense, therefore, the dirigible is hopelessly at a disadvantage, and as its value as to carrying power is in direct proportion to its size, this must always be the case.

Speed. No comparison is possible where *speed* is concerned for the slowest aeroplane travels as fast or faster than the most speedy dirigible—about 43 miles an hour—while speeds in excess of 99 miles an hour already have been reached by the aeroplane with every prospect that, with the developments of the next few years, the speed of flight will be materially increased.

Strategic Advantages. Any strategic advantages the use of the dirigible might possess vanish completely in the face of such superiority in speed, which means a proportionately greater ease of maneuvering. There appears to be no reason why one $5,000 aeroplane could not easily be the means of destroying a $500,000 dirigible in time of war, while if beset by a fleet of these high-speed flyers, its destruction would be inevitable. The huge gas bag of an airship forms a mark that would be difficult to miss and even small arm fire would quickly destroy the value of the envelope as a supporting medium. The wings of an aeroplane, on the other hand, could be riddled with bullets without seriously impairing its ability to stay aloft. Now that the only limit to altitude flights is the aviator's endurance, there could be no possible escape for the dirigible. Although the latter, by the sudden release of ballast, can shoot up to great heights, the aeroplane can rapidly follow, as shown by Johnstone's flight to a height of more than 9,000 feet in a little over 25 minutes, and the crew of the dirigible is quite as susceptible to the physiological effects of the sudden change of barometric pressure as is the operator of an aeroplane—more so, in fact, as the change may be more sudden.

Passenger Service. Where passenger carrying is concerned, the developments of the past year show conclusively that the aeroplane can be given more than sufficient capacity for all military purposes. Breguet has succeeded in carrying twelve passengers in a comparatively moderate-sized machine, a number which can undoubtedly be increased, so that with its greater speed the aeroplane can more than compete with the dirigible as a passenger carrier. It does not require a regiment of men to help it alight or get away, and a small building will house it. If necessary to stow it in a restricted space, this may be done by dismounting the wings, the reverse process of assembling being so simple that the machine can be made ready for service in an hour's time.

Behavior in a Wind. When the aeroplane first came into prominence several years ago, its then present and future possibilities were very much belittled. The general consensus of opinion at that time of those who pinned their faith to the dirigible was that the aeroplane was merely a scientific toy—an experiment of the laboratory being carried out on a larger scale and nothing more. There seemed but little question that the airship was the most practical means of navigating the air; any comparison was one-sided and all in favor of the dirigible, for up to that time aeroplane performances had been confined to very short flights, usually with the aviator alone, and then only in the calmest weather. In contrast with this, the dirigible could remain aloft and combat winds that were then considered dangerous to the aeroplane, so that despite the fact that the dirigible has never represented anything but a most precarious and costly method of navigating the air, it was the most practical means of doing so available up to about 1906. The comparatively few years that have intervened have totally changed its status. Flights such as those made by Johnstone and Hoxsey at the International Meet in the fall of 1910, during which they were driven backward 40 and 30 miles, respectively, by a wind exceeding 50 miles an hour, after which both alighted safely, demonstrate conclusively that the aeroplane is now vastly the superior of the dirigible as far as keeping to the air in stormy weather is concerned. Under the same conditions, the motors of the most powerful dirigible ever built would have been helpless; an attempt to land would have meant inevitable destruction of the airship and probably the death of some of its crew, and yet, as the ocean was right at hand in the case in question, there would have been no alternative but to land despite the gale that was blowing.

Portability. Where it is impractical for strategical reasons to fly from the point at which aeroplanes are permanently stationed, they may be partly dismantled by folding the wings, may be placed on a specially designed automobile as shown in the Bleriot war monoplane Fig. 2, and be transported a considerable distance in less time than is necessary to get an airship out of its shed, thus approaching an enemy's location from an unexpected direction. In the same manner, they can always be carried along as a regular part of an army's field equipment, and may be sent aloft at short notice. They may also be carried on naval vessels in the same capacity and undoubtedly this will be the case in the near future, as the result of the highly successful experiments made in this country. At a considerable height, well within the range of the aviator's vision, an aeroplane is not alone an extremely difficult thing to hit, but likewise a very difficult thing to see at all and can be followed only by close concentration on the part of the observer. The dirigible, on the other hand, is always plainly visible, even at heights that would render observations on the part of its crew of very little value. Unless struck in a vital part, disabling the motor or killing the aviator, a chance shell would not interfere with an aeroplane's flight, but a single rent in the envelope of a dirigible of the flexible type would terminate its voyage then and there, the Zeppelin multi-cellular type with its numerous independent gas bags being free from this disadvantage.

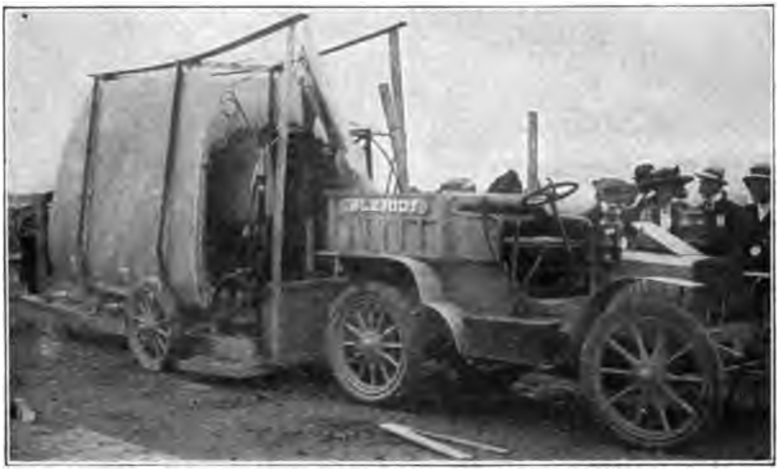

Fig. 2. Bleriot Military Monoplane, Showing Portability Feature

But despite its manifold shortcomings, the various Zeppelin disasters, the numerous serious mishaps that have befallen the

German military dirigible Parseval, and the several misfortunes of different French airships, governments will probably continue to build dirigibles. The French and German military departments, however, having had a wide experience in this field, are devoting a great deal more attention to the aeroplane, France having been the first to officially adopt this fourth arm as a part of its military service, and now having an aerial fleet far outnumbering that of any other nation. England, too, will probably question carefully further developments along this line in view of her recent experience with the huge British naval dirigible Mayfly, which, although completed late in 1911 at an enormous cost, was completely wrecked at the first attempt to take it out of the shed. Through what has generally been regarded as ultra-conservatism, the United States has not had to pay for the experience which European governments have paid so highly for—its one small dirigible is said to have cost but $30,000, or less than the expense of fitting up one of the large French or German airships—and there appears to be but scant prospect that any more money will be spent in this direction in America.

Recent Developments in Dirigibles. *Types.* Despite the destruction of the various Zeppelin airships, their builder has never lost faith in the rigid type of dirigible he has evolved, and interest in aerial passenger transportation in Germany is on the increase rather than otherwise. The Zeppelin VI made 34 trips, but bad weather was so constant that she was able to sail only on 19 days out of the total of 25 that the ship was in commission before being destroyed. On these trips, 406 passengers were carried, in addition to a crew consisting of a captain, two pilots, and five engineers, or an average of 20 persons per trip. The trips varied from 50 to 125 miles each, and some idea of the financial return may be gained from the fact that during the short time it was in operation, the ship brought in $19,000, of which $11,215 was profit. So promising is the financial reward accruing from the operation of aerial passenger lines that there are several in Germany, and if press reports appearing during the winter of 1911 have a basis of fact, a similar enterprise on a smaller scale should be established during 1912 between Philadelphia, New York, and Atlantic City, it being reported that airships of the Parseval type had been acquired for the purpose. The Zeppelin Airship Construction Company has been incorporated in Germany with $3,000,000 capital to carry forward Count Zeppelin's work, and an immense plant has been established at Friedrichshafen for the construction of the huge rigid dirigibles. One of the first that was built there was the Deutschland II, which went into commission in the fall of 1910; a great deal was expected of her during the following year when she was to be stationed at Düsseldorf, first for making excursion trips of 100 to 150 miles, and ultimately to carry on a regular passenger service between Düsseldorf and Hamburg, but she was wrecked after a comparatively short time in commission in much the same manner as most of her predecessors. The Schwaben was put into service shortly after and proved very successful, having made 140 trips during 1911, carrying a great number of passengers, her immunity from accident being due in large part to the improved methods of handling the ship in docking. The Deutschland II was 485 feet long by 46 feet in diameter, the Schwaben being slightly smaller. Duralumin, a new alloy of aluminum of greatly increased tensile strength, has been adopted for the frames, increasing the passenger capacity to 26, as compared with 20 in the older ships. The design has also been modified by allowing sufficient space between the outer covering of weatherproof cloth and the silk gas bags to permit of a constant draught of air over the latter, thus keeping the temperature approximately uniform and preventing sudden expansion or contraction of the hydrogen.

It will be apparent from this that Germany has commercialized the dirigible on a large scale—in fact, there is little or no conception here of the amount of money that is being expended on the airship abroad, as may be noted from the following resumé of some of the large dirigibles now in existence.*

The huge French airship Clement-Bayard II and the English Morning Post were largely the result of popular rivalry between the two nations in this field. The latter has a capacity of 353,000 cubic feet and, with the exception of the rigid Zeppelins, was the largest airship ever constructed, up to the time of its building. It has since been surpassed by the German non-rigid Krell I, a giant of 459,160 cubic feet capacity. The experiences of military service have evidently shown the necessity of greatly increasing the size of the vessels, but not to the extent that obtains with the passenger-carrying craft. Thus the new French Captaine Marechal, named after the Republique's unfortunate commander, displaces 254,304 cubic feet, or nearly three times that of La Republique, while the new Italian military dirigible has a displacement of 282,560 cubic feet.

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*"In existence" must be regarded as referring only to the time at which it was written. It only takes a few minutes to demolish a dirigible, but months or a year may be necessary to rebuild it.—Ed.

As a general rule, the French have devoted more attention to the construction of airships than to the art of handling them, so that during last year's military maneuvers, some of their dirigibles had narrow escapes. With the exception of the small Zodiacs, the French military airships are rarely used to the extent that one would expect. In England, airships have been developed by the army on a small scale. As a sea power, England is naturally concerned with the development of the dirigible as an auxiliary to the navy. Big though they were at the very outset, the Zeppelins have grown from 59,160 to 706,400 cubic feet capacity. The British naval dirigible begins at the latter figure. The latest passenger airship built for Belgium by the French Astra Company, the Ville de Bruxelles, displaces about 282,560 cubic feet. On the other hand, the most advanced experimental types, the German Krell I and the British Mayfly, were designed solely for military purposes. The new Belgian ship, however, is an interesting type.. The single large propeller of the classic La France of 30 years ago is still retained, in addition to which there are the two elevated side propellers, driven by a separate motor, as in the Clement-Bayard design, but somewhat smaller in size. The result is that the ship remains under control even after the front propeller is stopped in landing. The Parseval form of envelope, characterized by the blunt, ovoid bow, is employed. It is hardly necessary to discuss the comparative merits of the so-called flexible, semi-rigid, and rigid systems of construction in this connection. The very largest sizes must, of necessity, be rigid. For the smaller airships, each system has its own advantages and disadvantages. England and France now have rigid types, as well as Germany. France is the home of the dirigible, but the French, who were responsible for its invention, have not developed lighter-than-air craft as systematically as the Germans.

Refinement of Details. The tremendously increased size of the up-to-date airship has tended to greater refinement of detail. Donkey engines are becoming a common feature of their motor equipment, the Krell I, the Akron, Vaniman's transatlantic dirigible, and Brucker's transatlantic trade-wind ship, the Suchard, all being fitted with them. The gas bags of both rigid and non-rigid dirigibles are subdivided into compartments like a ship, this construction having been first introduced in the Zeppelins. Multiple balloonets are also being adopted in greater number, the good features of one ship being promptly copied in another. Thus, the English Zeppelin "Mayfly" adopted the propeller mounting of the Krell I, the object being to avoid long transmissions. In shape, it also approached the non-cylindrical form, the Zeppelin, however, still remaining essentially cylindrical. The larger the ship, the more elaborate is its equipment. Wireless telegraph apparatus is now carried by the Zeppelin passenger ships as well as by the military dirigibles, so that the navigator may constantly keep in touch with meteorological stations and be kept informed as to the weather. Valuable experiments have been carried out by the Zeppelin company to guard its airships against atmospheric electricity. In fact, the Zeppelin company profits by its experience and tries to prevent the same accident being repeated. Thus, the new Deutschland had an increased dynamic lift, an improvement that was made immediately following the disaster to its predecessor. As a result, this dirigible rose to a height of 3,800 feet without casting over any ballast; this lift later proved insufficient and the Schwaben was further improved. Probably the Zeppelin type would be still better if it had a continuous car like the Akron, containing the motors and crew, in place of two cars which are really a legacy of the old spherical balloon. Adherence to type has hampered the development of the airship, just as it kept back the improvement of the railway car. Just as early railroad coaches were merely enlarged horse-drawn coaches, so the modern dirigible, in a sense, is still an enlarged, elongated, spherical balloon, equipped with a motor. Obviously, an airship should have the same unbroken lines below as above to insure speed, and this idea has been carried out by Vaniman in the Akron.

Air Pilots. To guide one of these huge craft through atmospheric disturbances of more or less violence requires considerable skill, and the long period of apprenticeship necessary in the construction and piloting of a dirigible—a period which is longer, strange as it may seem, than in the case of the aeroplane—accounts for the slow development of the types with which we are familiar. Although the German army experiments daily in the air, the tactical handling of dirigibles is still shrouded in mystery. No doubt, there are definite rules to be followed, but what they may be can only be surmised. Even night trips are said to be frequent with the German military dirigibles.

Major von Parseval has said of the competent air captain: "He must know exactly the speed of his ship and of its maneuvering ability. Above all, he must have a nice sense of the responsiveness to the vertical steering apparatus, and be able to estimate the ship's carrying capacity with considerable accuracy."

On trips from Munich, the L. P. VI covered 3,000 miles and, with frequent small injections of fresh hydrogen, has remained inflated for twelve weeks. On one trip she combated a gale of 34 miles an hour, a speed hardly exceeded by the vessel at its best. The captain made considerable headway by tacking into lulls, keeping the harbor well to leeward, ready to return and land at a moment's notice. This was airmanship of a high order. This ship has had the unique experience—for air craft—of being chartered for a special trip to Kiel, which it is proposed to make as important an airship station as it now is a naval base. And the ship has also added to its revenues as a passenger carrier by serving as a background at night upon which to throw stereopticon advertising.

Air Harbors. With the aeroplane, the question of housing is a simple matter, Fig. 3, but as each new military airship has become larger, the problem of sheltering it has become more difficult. Fig. 4 gives some idea of the size of the harbor for a modern dirigible. It has resolved itself into a question of establishing a number of permanent harbors in Germany. These are on a truly colossal scale, those at Königsberg and Thorn, fortresses on the German frontier, have been designed to house ships half as large again as the biggest vessels now in service. For craft so huge, portable sheds are out of the question. Permanent harbors must be constructed, which will serve as bases for craft having a wide radius of action. The new Zeppelin air harbors are on an elaborate scale. To the stations already established at Düsseldorf and Baden-Baden, a number of others are now being added, and smaller cities that can not afford to provide great harbors with sheds are establishing landing places with moorings, and aerial beacons will shortly become common, judging from the success of those in use at Spandau and Munich. Dirigibles are started on their journeys and docked by large

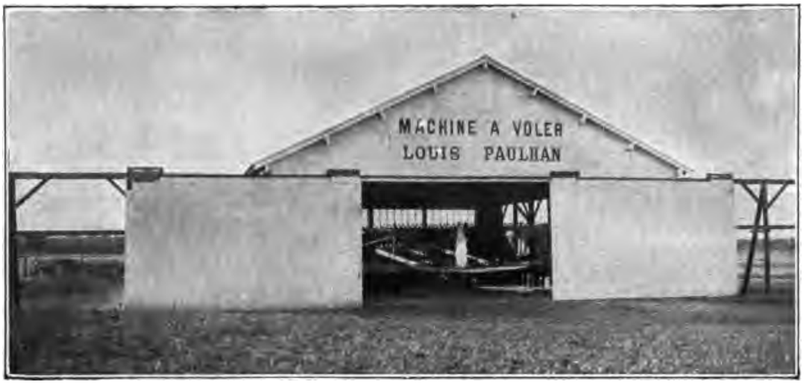

Fig. 3. An Aeroplane Hangar

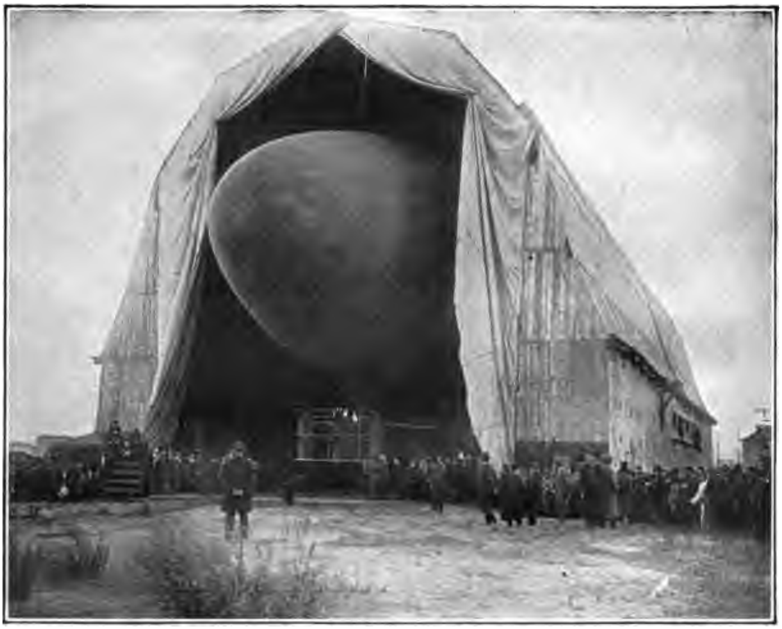

Fig. 4. Immense Harbor Necessary for Vaniman's Transatlantic Dirigible "Akron"

forces of trained men, but even long practice has not enabled them to handle such huge air craft as the Krell I and the Schwaben, with ease. The docking of a big dirigible is a ticklish operation at best and is made dangerous by a cross-wind, only the new system of anchoring devised for the Schwaben having prevented damage to that ship. To cut down the expense necessarily entailed in maintaining such a large force, the Krell I is docked partly with the aid of electric winches, and this is something that will probably undergo considerable development.

Just now, inventive ingenuity is concentrated on the airship itself, but the time will soon be ripe for a consideration of the problem of handling the ship by machinery entirely. Of these problems, probably the most difficult is that of anchoring an airship in a high wind—in the Krell I, it is solved by employing a multiple anchor cable which is led to the nose of the ship and there divided. The 24 single ropes into which it separates are fastened all round the envelope, where the diameter is not less than 20 feet.

Improvements of Design. Where the construction itself is concerned, all other difficulties of building large airships are summed up in the well-known fact that, as a structure increases in size, the margin of safety does not increase in proportion. In other words, to build a successful airship 300 feet long on exactly the same lines as one 150 feet long, it would not be correct, from an engineering viewpoint, to scale up the parts of the smaller craft to the proportionate size of the larger. The big Morning Post, which is a Lebaudy of 353,200 cubic feet displacement, is simply a Lebaudy of 105,960 cubic feet, enlarged line for line. There is but a single car, very close to the envelope at that. But it can not be denied that the crossing of the English Channel at its widest part and its journey from Moissons to Aldershot in five hours and in a strong wind, shows that size must be very greatly increased before the structural danger point is reached. The Krell I seems to embody the opposite principle, namely, that an increase of size beyond 105,000 cubic feet involves the very best efforts of the engineer to increase the factor of safety proportionately. There are not simply two cars instead of one, but three, so suspended that the pull on the gas bag is all in a vertical direction, differing radically from the oblique suspension and pull in the Morning Post. Hence, in the Krell I a minimum strain is imposed upon the envelope. It is true that the latter ship is uncommonly slender in spite of the absence of the stiffening frame on which the Morning Post essentially relies. Whatever may be the shape of envelope, the material is subjected to tensile stresses only.

The new German military dirigible M. IV is provided with a very substantial stiffening frame, so designed that the load is divided in half. Its engine power has also been very substantially increased. Zeppelin's Deutschland II was considerably lightened without any fundamental change in plan or material, the girders being redesigned more effectively. The British dirigible Mayfly, of very similar type, was built of duralumin, the result being that its engine power was higher, and that its radius of action for the same displacement should have been greater. Both the Deutschland and the Mayfly were nearly identical in design with the first Zeppelins of 459,000 cubic feet only. In neither case was it considered necessary to increase the margin of structural safety with the size, and both were wrecked after a short period, the British ship before it had seen any service.

The foregoing will suffice to give some idea of the exceptional activity that characterizes the present development of the dirigible abroad, as compared with the utter apathy with which it is viewed in this country. Americans who have not gone abroad have never had an opportunity of seeing a modern dirigible as exemplified by the German and British types referred to above, but if the American service mentioned should prove successful, those in the East may see similar dirigible airships in passenger service.

REWARDS OF AVIATION

Human nature is so constituted that men may be found to attempt anything if the financial reward be sufficiently large; and it is this spirit that makes the impossible of today the achievement of a week or so hence, as is strikingly illustrated by the rapidity with which records were surpassed during the past two years. In reviewing the latter, due credit must be accorded the powerful incentive to extraordinary effort represented by the cash prizes offered both in this country and abroad. Despite the large sums given, the breaking of a record has immediately brought forth offers of still larger amounts. The achievements of the past few years have been paid for at a cost exceeding a million dollars in prize money alone, and it goes without saying that this has spurred aviators on to efforts that probably would not have been made otherwise until some time later. The following are some of the prizes won during 1910 and 1911, as well as a number still standing or to be offered during 1912.

Prizes for Flights. The International Trophy, Fig. 5, was offered by James Gordon Bennet and was first competed for in connection with the International Aviation Meet, at Rheims, France, where it was won by Glenn H. Curtiss in a Curtiss biplane in August, 1909. In the following year it was competed for at the International Meet held at Belmont Park, New York, in October, 1910. In this event Leblanc broke all records for distances up to 95 kilometers, but when he had the victory in sight with several minutes lead, the gasoline supply failed and his machine dropped on a telephone pole. The machine was a 100-horse-power Bleriot, and was completely wrecked, although Leblanc escaped without injury. This allowed Claude Grahame White to win in a 50-horse-power machine of the same type.

The prize is offered for the fastest time over a three kilometer circular course and is to be competed for in the country of the previous winner. The trophy is to be awarded permanently after having been won three times consecutively by an aviator of the same nationality. As Grahame-White is an Englishman, the third competition was accordingly held in Great Britain in July, 1911, the trophy being won by an American for the second time. This was Weyman, who drove a Nieuport monoplane equipped with a 100-horse-power Gnome motor. The distance was originally 100 kilometers, but as the staying capacity of the aeroplane developed so rapidly, this was held to for only two years, the distance in 1911 being 150 kilometers.

The first substantial prize to be won in this country was that of $10,000 awarded by the *New York World* to Glenn H. Curtiss for his flight, on May 29, 1910, from Albany to New York, a distance of 148 miles. This immediately led to the offer of $25,000 by the *New York Times* and *Chicago Evening Post* to the winner of a race between the two cities, the only conditions being that there must

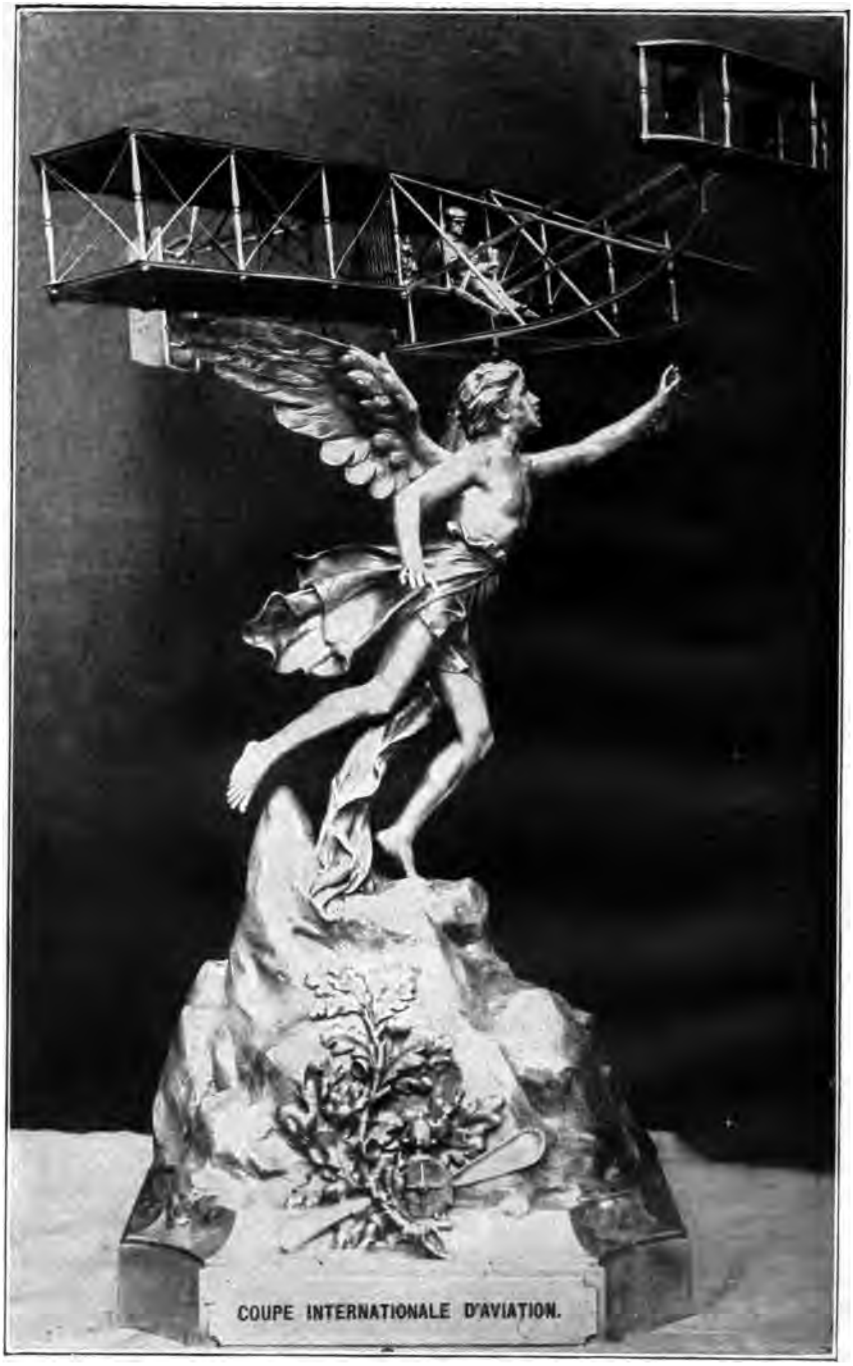

Fig. 5. Gordon-Bennett International Trophy

be at least three competitors and that the total time for the trip must not exceed 168 hours. This amount was increased by the offer of the Pennsylvania Aero Club of $1,000 for a week's exhibition of the winning machine, with a further increase of $1,000 offered by Clifford B. Harmon to the first aviator to keep the air for 500 miles consecutively in that race, bringing the total winning possible in this event to $27,000. This was exceeded by the offer of $30,000 by the *New York World* and the *St. Louis Post-Dispatch* for a flight between St. Louis and New York, and the $50,000 prize put up by William R. Hearst for the first successful flight from the Altantic to the Pacific in a dirigible, the latter having the great disadvantage that the cost of a machine capable of making the trip would exceed by several times the amount of the reward, whereas the cost of an aeroplane is but a fraction of some of the larger prizes. It was later extended to cover an aeroplane flight as well.

Two attempts were made to win the Hearst $50,000 prize during the fall of 1911, but neither succeeded in complying with the conditions, which called for the crossing of the continent in 30 days. C. P. Rodgers in a Model "B" Wright machine made the journey from New York to Pasadena by way of Chicago, Kansas City, Dallas, and San Antonio in 59 days, the distance being 3,390 miles. Although the airline distance is only 2,540 miles, it will be some time before an aviator will feel sure enough of himself to follow an airline route. Rodgers was greatly delayed by numerous mishaps and also by stopping for exhibition purposes. He was convoyed by a special railroad train, one car of which was fitted as a machine shop. On attempting after a rest at Pasadena to make the remaining 25 miles to the coast at Long Beach, his aeroplane fell and the plucky aviator nearly lost his life. Notwithstanding his machine was almost a total wreck, it was again repaired and Rodgers finished his journey about a month later, thus completing what must be considered a very noteworthy flight.* Fowler, who started from the west coast, was even more unfortunate and had to give up the attempt to cross the mountains after several trials, taking the southerly route instead. His ill-luck still pursued him, so that after more than three months' work he had succeeded in getting no farther than New Orleans. He subsequently completed the trip, landing at Jacksonville, Florida.

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*After completing his coast-to-coast journey, Rodgers had been making almost daily exhibition flights over the water at Long Beach, California. On April 3, 1912, he misjudged his proximity to the surf at the end of a "volplane" from a height of 200 feet, dashed into the water, and was almost instantly killed.

That these prizes, on the one hand, are not unusually large, nor, on the other, merely prizes that may be won in the indefinite future, is amply evidenced by some of the winnings of foreign aviators in the past. The most prominent of the latter was naturally the $50,000 prize won by Paulhan in his flight from Manchester to London, April 28, 1910, while Wynmalen, the Belgian aviator, won

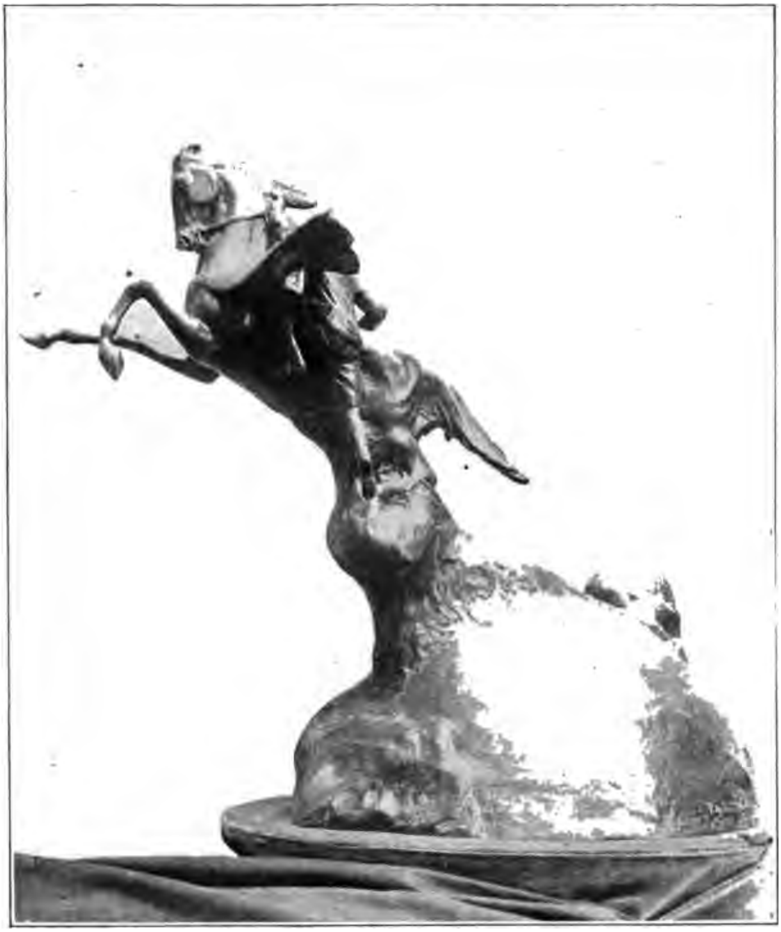


Fig. 6. Michelin Trophy for Longest Continuous Flight

$20,000 on October 16, 1910, by his flight from Paris to Brussels and return in less than 36 hours. The Michelin prize of $20,000 together with the Michelin trophy, Fig. 6, were gained by Tabuteau for his flight of 365 miles, Fig. 7, the longest continuous flight made during 1910 but which was surpassed by a substantial margin in 1911. Fig. 8 shows the enormous gasoline tank necessary for this performance, while Fig. 9 shows the provisions for protecting the operator. It was in attempting to win the Michelin prize that Moissant lost his life at New Orleans, on December 31, 1910. Another Michelin prize of $20,000 is for a flight from Paris to the Puy de Dome with a passenger. This is a mountain 4,800 feet high and about 217 miles in an airline from the French capital, the conditions being that the aviator must circle the cathedral spire at Clermont-Ferrand on the way, and that the trip must not consume more than six hours. Several attempts to win this prize have been made without success. Weyman flew within 13 miles of the goal on September 7, but lost his bearings and was compelled to descend owing to fog and rain. Morane, who was to have competed at the International Meet near New York, made an attempt on October 22, but was seriously injured through the fall of his 100-horse-power Bleriot soon after leaving Paris. It was finally won in an M. Farman biplane in the summer

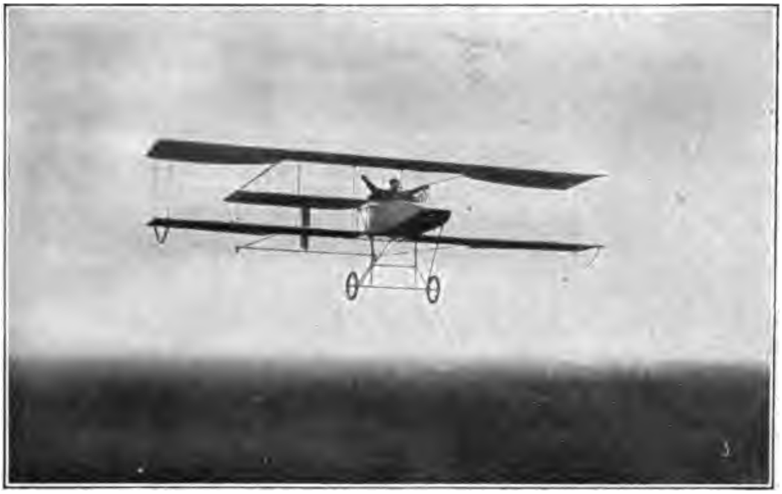


Fig. 7. Tabuteau, Winner of Michelin Prize in 1910, in Flight

of 1911. Still another prize and the British Michelin trophy, Fig. 10, were won by Cody in his biplane, when he covered 194.56 miles in 4 hours and 50 minutes.

Prizes of similar amounts are not lacking in this country; among them may be mentioned one of $20,000 offered by the Aero Club of Washington to the Wright Brothers for a flight from New York to Washington, if they will enter one of their machines against a Curtiss, while a prize of $10,000 is offered by James H. Moore, of Rochester, New York, for a flight from that city to Detroit, Michigan. The conditions in this case are to be left to the decision of a committee of aviators. More than one attempt has already been made to win this by local talent, but with scant success. Numerous prizes

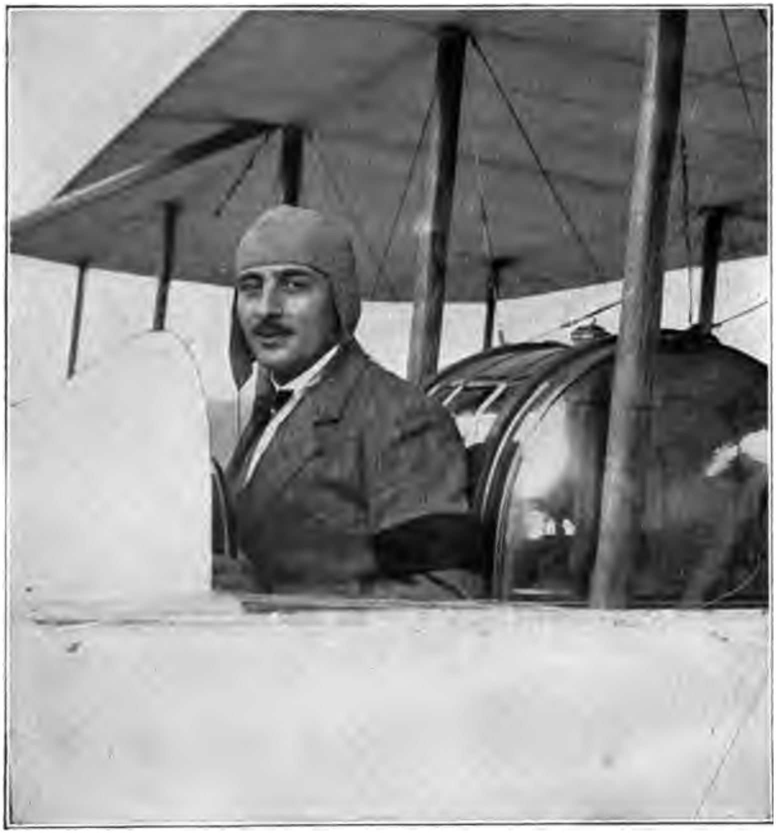


Fig. 8. Close View of Tabuteau Showing Immense Gasoline Supply Tank

have also been offered and won for altitude flights, Brookins placing $5,000 to his credit by his record-breaking ascent at Atlantic City on July 9, 1910.

Naturally, the largest aggregate amounts are those offered at prominent meets, the winnings of the aviators at the International Meet at Belmont Park in October, 1910, having reached a total of approximately $200,000, the participants in this case also having been awarded a share of the gate receipts. Before the opening of the meet, $50,000 was appropriated for cash prizes, as follows: three prizes of $4,500 each for speed, altitude, and distance; an altitude record prize of $5,000 or $10,000 for the aviator first to reach

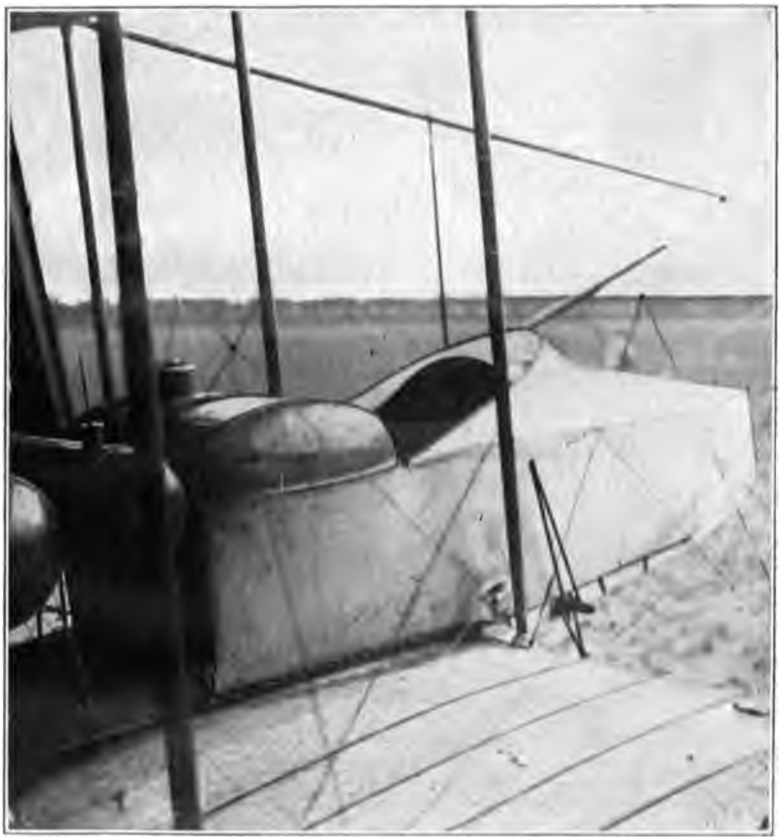


Fig. 9. View of Operator's Seat in Aeroplane Designed for Altitude Flights, Showing Means of Protection from Extreme Cold

10,000 feet; in addition there were what might be termed consolation prizes amounting to $250 for each hour the aviators were in the air during the duration, speed, and altitude tests. (See Fig. 11.) These were supplemented by correspondingly large amounts

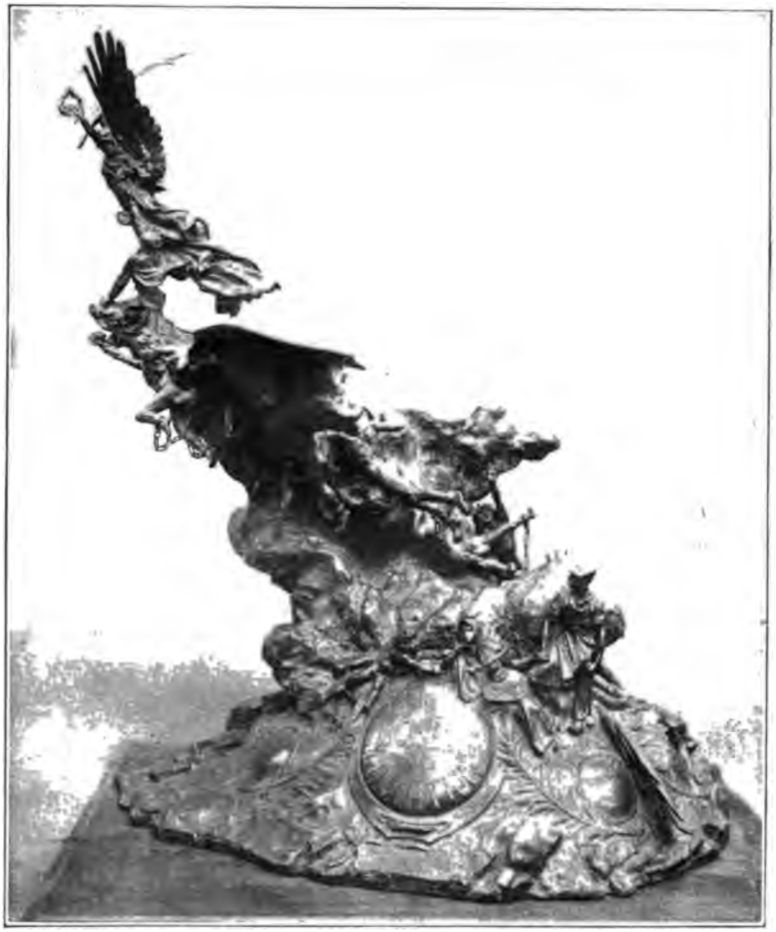
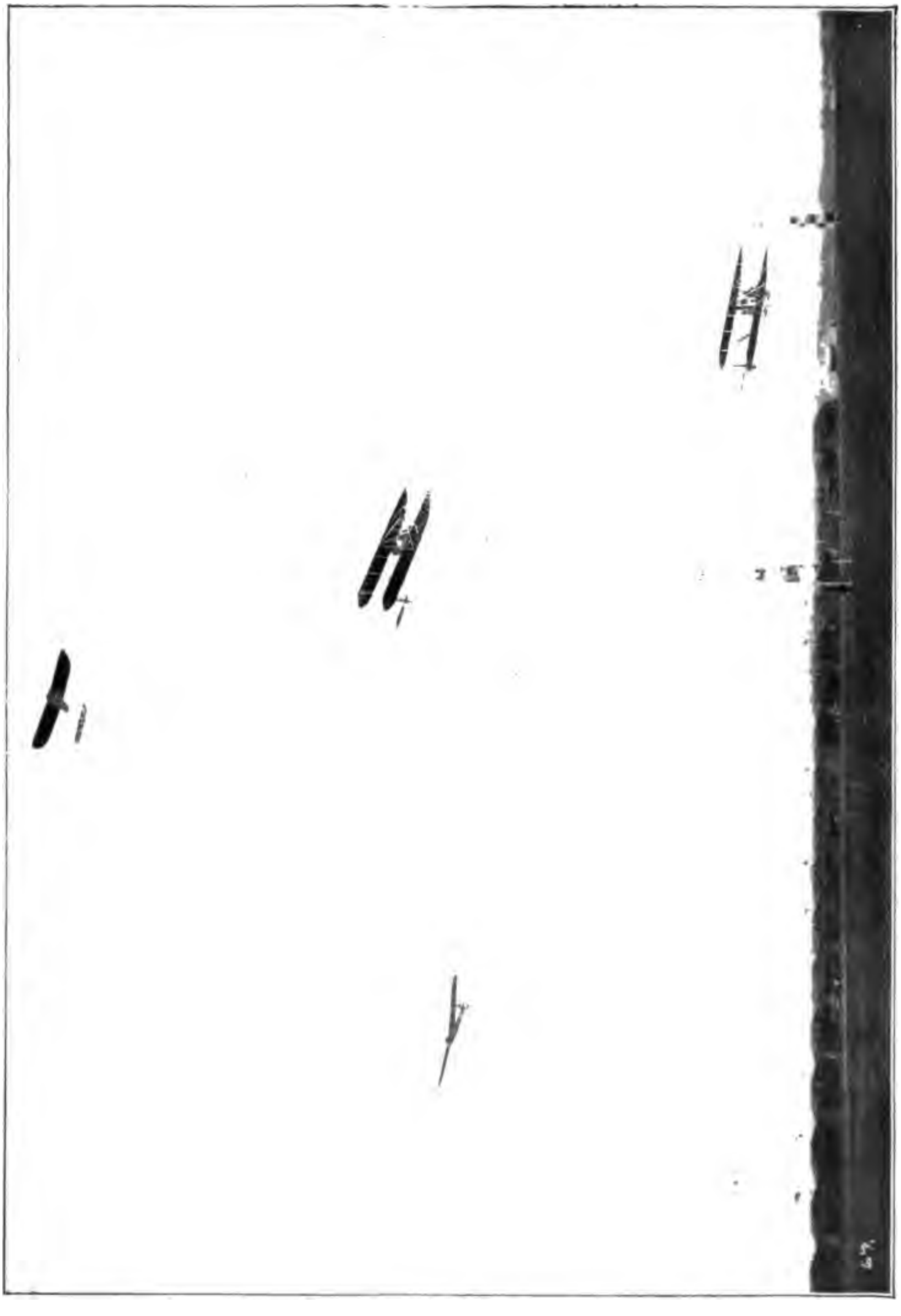


Fig. 10. Michelin British Trophy for Distance Flight

for cross-country flights, as well as prizes for passenger carrying, relay messenger service, slow flying, quick starting, and other feats, besides which there was a prize of $10,000 for the winner of a race from Belmont Park round the Statue of Liberty and back.

At smaller meets, the amounts offered have been proportionately



large, the *Boston Globe* offering $10,000 for the fastest trip over the water from the aviation field at Atlantic City round the Boston Light and back on the occasion of the Harvard Meet near Boston, in September, 1910. In addition to this, first, second, and third prizes of $3,000, $2,000, and $1,000 were offered in the speed and altitude events, and $2,000 and $1,000 in the duration and distance competition, the making of a world's record, in either case, adding $1,000 to the amount. Other prizes were $1,000 and $500 for the slowest lap of the course, with smaller amounts for the quickest start, accuracy, and the like, the total offered aggregating $41,000. At the Baltimore Meet, in November, 1910, there was one prize of $10,000, two of $5,000 each, three of $3,500 each, one of $1,500, and so on down, totalling $32,700.

The Los Angeles Meet, in January, 1911, was the first to include prizes for dirigibles. In addition to one of $10,000, one of $7,500, and four of $5,000 each, for aeroplanes, a prize of $10,000 was offered for a flight by dirigible from Los Angeles to San Francisco, and another of $5,000 for a non-stop flight by a dirigible carrying more than two passengers from Los Angeles to San Diego and back. The distances are 450 and 150 miles, respectively. A $10,000 prize was also offered for a trip to the Atlantic Coast without landing, and $5,000 for the first balloon to land east of the Mississippi without having come to earth en route, with a further balloon prize of $2,500 for breaking Count de la Vaulx's record of 1,193 miles and $2,500 more for the first balloon to land within five miles of San Francisco. That the coast-to-coast balloon trip is not quite as chimerical as may appear at first sight from the mere offer of a prize, is evident from the fact that P. C. Thompson has offered $10,000 to Charles J. Glidden, the well-known balloonist, to finance a trip of this kind, and the offer has been accepted. A trophy worth $1,000 is offered for its successful completion, and no conditions are imposed other than that the start shall be made at some point on the Pacific and that the balloon shall land not less than 50 miles from the Atlantic Coast. H. H. Clayton, who acted as aid in the Pommern which won the International Balloon Race in 1908, will probably be the pilot.

As the intention is merely to chronicle the extremely strong incentive that is being offered in the form of substantial financial reward for record-breaking performances, no attempt has been made to detail a complete list of the prizes either won or offered, there being many of the latter in addition to those already mentioned, such as the prize of $5,000, for an aeroplane flight over the 90 miles of the Caribbean Sea separating Key West from Havana. This was awarded to McCurdy, one of the Curtiss aviators, although his motor broke down when he was within a few miles of Havana, having flown 87 miles.

Prizes for Improvements. No mention of the reward phase of aviation that has done so much to foster interest and bring about such startling achievements would be complete without at least a reference to prizes offered for improvements in construction, as the latter are, in reality, of more importance than achievements which merely illustrate what the present machines are capable of in the hands of skilled and daring aviators. The largest of these was granted to Edouard Nieuport as the winner of the French military competition for army aeroplanes; the bonus and value of the order for machines placed reached a total of $156,900; the second, Breguet, received $83,000; and the third, Deperdussin, $59,000.

In America, Edwin Gould has offered a prize of $15,000 for "the most perfect and practicable heavier-than-air flying machine, designed and demonstrated in this country, and equipped with two or more complete power plants (separate motors and propellers) so connected that any power plant may be operated independently, or that they may be used together." During the two years that this prize has been open, only one or two attempts have been made to win it. One of these was the Queen biplane, built near New York, which came to grief at the Nassau Meet, in September, 1911, after a short flight. The Short biplane, described under "Special Types," appears to be the first successful machine of the kind, though Sommer made a series of short flights on a machine fitted with two motors in the latter part of 1910. As both of these are foreign machines, however, they would not be eligible.

Cost of Equipment and Maintenance. While the rewards offered are unusually large and the winnings of some aviators have amounted to a small fortune in the course of little more than a year, the expenditures for machines and repairs are on a proportionately elevated scale. Following are some of the prices of the foreign machines exhibited at the Olympia show in London, in the latter part of 1910.

Wright biplane with Wright motor (English manufacture) $5,839; Farman biplane with Green motor $4,428; and with Gnome revolving motor $5,450; Voisin biplane with E. N. V. motor $3,796; Antoinette monoplane with Antoinette eight-cylinder, V-motor $4,866; Bleriot "Cross-Channel" monoplane $2,336; Santos-Dumont monoplane $1,460. In this country, the Wright machines list at $5,000 for the standard type and $7,500 for the racer with an eight-cylinder, 60-horse-power motor, and a glance over the prices of the machines exhibited at the Boston and New York shows during 1910 make it apparent that an investment of at least $4,000 to $5,000 is required in the purchase of a machine of any reputation. An American-made Voisin shown at Boston, listed $3,450; while an American Blerioplane was $3,750, which included instruction in its operation. As is the case with automobiles, however, machines may be had all the way from $1,000 up, with no limit on the latter.

In addition to the expense for machines, of which every prominent aviator owns several representing an investment of $25,000 or more, there is the cost of maintenance, viz, transportation charges for machines, and expenses for mechanics, fuel, oil, and repairs. Of these charges, the last is by far the most serious; transportation charges are high, as are also the expenses and wages of the mechanics; fuel and oil do not cut much of a figure, but the cost of repairs may exceed them all. Just a slight swerve in alighting, a gust of wind gets under the upraised wing tip and the other strikes the ground; the complete wing structure on that side is demolished—damage $250. Or again a propeller strikes an obstruction when the motor is started and cracks a blade—that means replacement at a cost of $50 to $85. Slight damage to the motor which puts it out of commission for a day or two may occasion the purchase of another to take its place—expense, anything from $500 up to $2,000; so that expenditures as well as winnings run up into many ciphers.

AVIATION RECORDS

Regardless of how great the achievements of the future may be, the record of man's flights in heavier-than-air machines during the first few years of his conquest will go down into history as representing an advance wholly unparalleled in any other field of endeavor in the same period. To have progressed from a flight lasting twelve seconds, during which the machine was not really under control, to flights limited in distance or altitude only by the endurance of the aviator or the amount of fuel carried, in little more than seven years, is certainly a record of performance unapproached.

Early Records. On the occasion of their first and second trials with the power-driven machine at Kitty Hawk, North Carolina, on December 17, 1903, the Wright Brothers made a flight of 12 seconds in a 27-mile wind. On the fourth trial, a flight lasting for 59 seconds and covering a distance of 852 feet was made the same day in a 20-mile wind and was the first actual flight by man in an aeroplane, demonstrating that the aviator had control of the machine. In August, 1904, at Dayton, Ohio, a flight of 1 minute duration was made, while on November 9, of the same year, a flight of 3 miles, lasting for 5 minutes 4 seconds, was made with the second power-driven machine ever built. During 1904, the Wright Brothers made 105 flights in all. In 1905 they made 49 flights, the performance of October 5, 1905, being longer than all of those preceding it put together. The time of this flight was 38 minutes 3 seconds, covering 24⅕ miles, which was the world's record for some time thereafter. This flight followed one of 11⅛ miles in 18 minutes 9 seconds, on September 26, 1905. No flights were made during 1906 and 1907.

A number of short practice flights were made at Kitty Hawk, North Carolina, in the spring of 1908, and on October 18, 1908, at Le Mans, France, a flight of 1 hour 54 minutes 53⅖ seconds was made, covering a distance of 62 miles, and on December 31, 1908, 77 miles were covered in a single flight in 2 hours 20 minutes 23⅕ seconds. No less than 100 flights were made at Le Mans, France, during which 36 people were taken up as passengers. All of these flights were made by Wilbur Wright, who was accordingly the first man to remain in the air for 2 hours.

Orville Wright made the first flight in a power-driven machine at Kitty Hawk, North Carolina, a mere glide of 12 seconds, and not to be compared for length or duration with glides previously made in planes without motors. As already noted, Wilbur Wright's first attempt was no better. On September 15, 1904, at Dayton, Orville Wright made the first turn in an aeroplane and five days later accomplished the first complete circular flight ever made. On September 9, 1908, at Fort Myer, Virginia, he flew at an altitude of

TABLE I

Aeroplane Records for 1909 and 1910

Aviator	Aeroplane	Date	Distance miles	Time H. M. S.	Remarks
Latham	Antoinette monoplane	July 19, '09	11		Fell into the English Channel.
Bleriot	Bleriot monoplane	July 25, '09	25	0 37 00	First cross-channel flight. Sangatte to Dover.
W. Wright	Wright biplane	Oct. 4, '09	21	0 33 33	Over Hudson River.
Paulhan	H. Farman biplane	April 18, '10	108	2 3 00	Chevilly to Chalons in two stages. Record for distance and duration to date.
White	H. Farman biplane	April 23, '10	117.2	2 50 00	London to Hodmore, one stop at Rugby, in London-Manchester race.
Paulhan	H. Farman biplane	April 23, '10	193	4 12 00	London-Manchester, 1st stage 117 ms. Average speed 44.34 ms. per hr.
Rolls	Wright biplane	June 2, '10	50	1 30 00	First round trip channel flight.
Curtiss	Curtiss biplane	May 29, '10	142.5	2 50 00	From Albany to Governor's Island in New York harbor. Flight made in three stages, time being total in air.
Hamilton	Curtiss biplane	June 13, '10	149.54	3 27 00	Governor's Island, N. Y., to Phila. and return—two stops, one accidental.
Curtiss	Curtiss biplane	July 11, '10	50	1 14 50	World's record for continuous flight over water. Carried pontoons and air bags. Made at Atlantic City.
Olieslagers	Bleriot monoplane	July 7, '10	158.45	3 39 29	Longest single flight to date. At Rheims, France.
Labouchere	Antoinette monoplane	July 9, '10	211.27	4 37 00	First to fly continuously for 200 miles.
Olieslagers	Bleriot monoplane	July 10, '10	244.04	5 3 05	First to fly for five hours continuously.
Moisant	Bleriot monoplane	Aug. 7, '10	25	0 32 00	First crossing of English Channel with passenger.
Le Blanc	Bleriot monoplane	Aug. 7, '10	485		Flew over circular course around France. Race from Paris and return, one stage per day regardless of weather. Time 10 ds. 12 hrs. 15 m. Longest stage 75 ms.
Aubrun	Bleriot monoplane	Aug. 7, '10	485		Finished 20 m. after Le Blanc over same course.
Curtiss	Curtiss biplane	Aug. 31, '10	64.75	1 42 00	From Cleveland, O. to Cedar Point, O., over Lake Erie. Carried pontoons and air bags.
Cattaneo	Bleriot monoplane	Aug. 13, '10	141.1	3 18 9	British record.
Johnstone	Wright biplane	Sept. 3, '10	101	3 5 40	American record made at Atlantic, Mass.
Brookins	Wright biplane	Sept. 29, '10	192.5	5 49 00	Chicago to Springfield, Ill., in two stages, first one of 88 ms.
Hoxsey	Wright biplane	Oct. 8, '10	109	3 33 00	Springfield, Ill. to St. Louis, in two stages, first one of 104 ms. American record.
Tabuteau	M. Farman biplane	Oct. 28, '10	289.3	6 1 35	First man to fly for 6 hours continuously. World's record.
Ely	Curtiss biplane	Nov. 14, '10	4	0 5 00	Flew from deck U. S. S. Birmingham to Virginia shore opposite Fortress Monroe.
Tabuteau	M. Farman biplane	Dec. 31, '10	365	7 0 00	Winning Michelin prize of $20,000. 42 other aviators competed. First won by W. Wright in '08—78 ms. in 2 hrs. 20 m.
H. Dutrieu	H. Farman biplane	Dec. 20, '10	105	2 33	Winner of "Femina" cup and prize—longest flight by a woman.

150 feet, making a world's record, while three days later he flew for 1 hour 14 minutes 24 seconds, covering 50 miles at an altitude of 250 feet, again establishing a record for altitude.

Records for 1909 and 1910. By the beginning of 1910, 2-hour flights had become so common and so many were made during that year that it would take a volume to record them; the most notable, however, are given in Table I.

Records for 1911. Flights became so numerous during 1911 that it would be out of the question to attempt to give more than passing mention to some of the most prominent. The number of licensed pilots in America increased from 26 in 1910 to 81 in 1911, while it is conservatively estimated that there are not less than 2,000 flyers in France, and that, during 1911, they made 15,000 flights, none of less than half an hour, covering a total of 350,000 miles.

Every world's record which 1910 had placed so far in advance of anything previously accomplished was left far behind. Garros mounted 13,947 feet; Beachey volplaned more than 12,000 feet; Fourney flew for 11 hours without stopping; Gobe exceeded the distance record by 12 miles in three hours less time, and without a stop; Helen, two weeks after becoming a pilot, flew 750 miles in 14 hours, including six stops for fuel—in fact, only four days after receiving his certificate he flew 665 miles in 12 hours and 40 minutes with three stops; Nieuport and Vedrines made a speed of 93 miles an hour; Prier flew from Paris to London, 223 miles, without a stop; Rodgers flew across the American continent by easy stages, a distance of 2,567 miles, from New York to San Francisco, while Fowler made half the distance in the opposite direction; and Atwood flew from St. Louis to New York, 1,155 miles, and immediately afterward made the flight from Boston to Washington, 460 miles. Between May 1 and October 1, Renaux was credited with 6,830 kilometers (4,098 miles), made in trips of 100 kilometers each, while Beaumont covered nearly 3,000 miles in the three great European races. There were five of these events in all: Paris-Madrid, 726 miles; Paris-Rome, 910 miles; the 1,073-mile European circuit; the 1,093 German route; and the Tour of England, 1,010 miles. Fowler completed his transcontinental trip by the end of February, 1912, landing in Jacksonville, Florida.

In addition to the most striking performances already mentioned, numerous notable flights were made in America on American-built machines. Though it took 12 days in all, Atwood's flight from St. Louis to New York occupied only 28 hours 53 minutes actual flying time, during which the only attention required by the engine was the re-babbiting of two bearings. Lieutenants Ellyson and Towers of the United States Navy Aeronautical Corps made a non-stop flight of 138 miles over Chesapeake Bay at 56 miles an hour in the Curtiss navy hydroaeroplane, having just previously made a non-stop flight of 75 miles. Hugh Robinson made the hydroaeroplane record of the year by his flight of 314 miles down the Mississippi in three days, carrying mail. McCurdy flew from Key West, 89 miles, over the Caribbean and would have landed in Havana a few minutes later, but for the breaking of the crank case of his motor. Parmalee and Lieutenant Foulois flew 106 miles with army despatches from Laredo to Eagle Pass in 2 hours 10 minutes, returning over the same rough country with but one stop. Beachey and Robinson raced from New York to Philadelphia, 83 miles, and Atwood flew from Lynn to Providence over the water in 2 hours 45 minutes. M. B. Sellers flew with a motor developing a scant 6 horse-power, thus carrying the exceptional weight of 41 pounds per horse-power.

The seventeen aeroplane builders in France turned out over 1,300 machines in 1911, the motors fitted to them having an aggregate horse-power in excess of 60,000. Of this total, 813 of the aeroplanes were produced by only five of the leading French makers. The American production is estimated at 750 machines, but of these more than two-thirds were built in back yards, less than 200 having been turned out by the Wright, Curtiss, Burgess, and a dozen or more smaller concerns. The actual total was 174, of which 58 were for private use, 105 for exhibition purposes, and 11 sold to various governments. Out of the total produced by the five leading French builders, 410 were sold to various governments, 367 were used in exhibitions and in school work, and 46 for sporting purposes.

No new records were made in America in balloons or dirigibles during 1911, though two big races, the National and the Gordon-Bennett, were held from Kansas City. Germany and France lead in the construction of big airships, Germany having 26, either belonging to the government or available as a military reserve, while

France has 15. England, Russia, Austria, Italy, Spain, Belgium, and Holland have 25 more. The French airship "Adjutant Reau" holds the record for distance, duration, and altitude, making a continuous trip of 550 miles in 21 hours 20 minutes, during which an altitude of close to 7,000 feet was reached. The German passenger-carrying ship Schwaben made 140 trips, covering 12,670 miles.

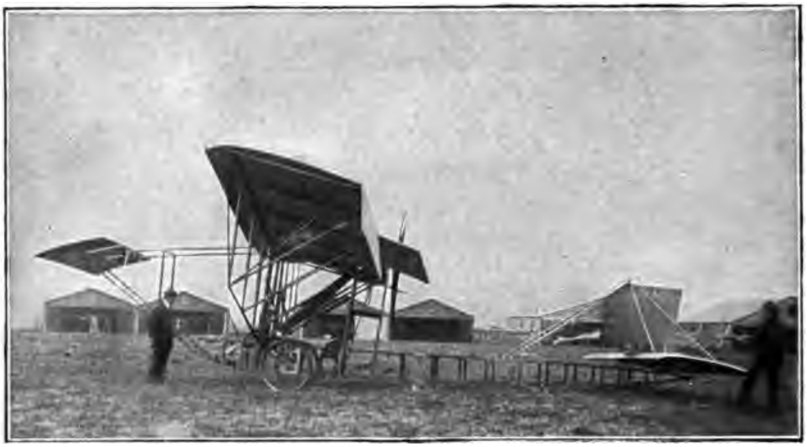


Fig. 12 Side View of Bleriot "Bus"

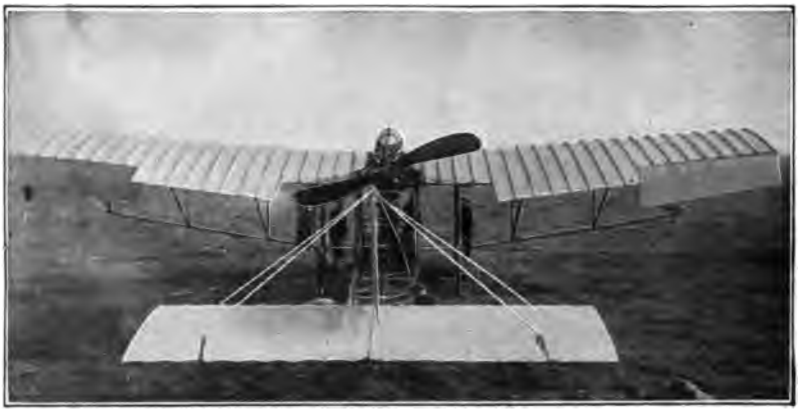


Fig 13. Front View of Bleriot "Bus"

Passenger Records. Up to 1908, all flights had been made in machines carrying the aviator alone. The first flights with passenger, lasting more than a few seconds, were those of Wilbur Wright at Fort Myer, Virginia, in September, 1908, when he carried aloft first, Lieutenant Lahm for 6 minutes 26 seconds, then Major Squier, U. S. A., for 9 minutes 6 seconds. Later in the same month, at Berlin, he carried a German army officer aloft for 1 hour 35 minutes 47 seconds.

March 5, 1910, Henri Farman succeeded in carrying two passengers in the air, or three persons all told, for 1 hour 2 minutes 25 seconds. On April 20, Roger Sommer, in a Sommer biplane, carried four people—one a woman—for five minutes, while on August 29, Louis Breguet took up six persons all told, the total weight sustained being 923 pounds. In the fall of 1910, Bleriot built a machine to carry regularly eight passengers, *i. e.*, nine persons all told. Figs. 12 and 13 show side and rear views, while Fig. 14 shows details of the car. This machine, which was dubbed the "Bleriot Bus," was very successfully tried out in the early spring of 1911, making a number of flights which showed its ability to make a good speed despite the great amount of weight carried. This was in February, 1911, and scarcely a month had passed before Louis Breguet made an astounding flight of 3 miles with 11 passengers besides the aviator, or 12 people in all,

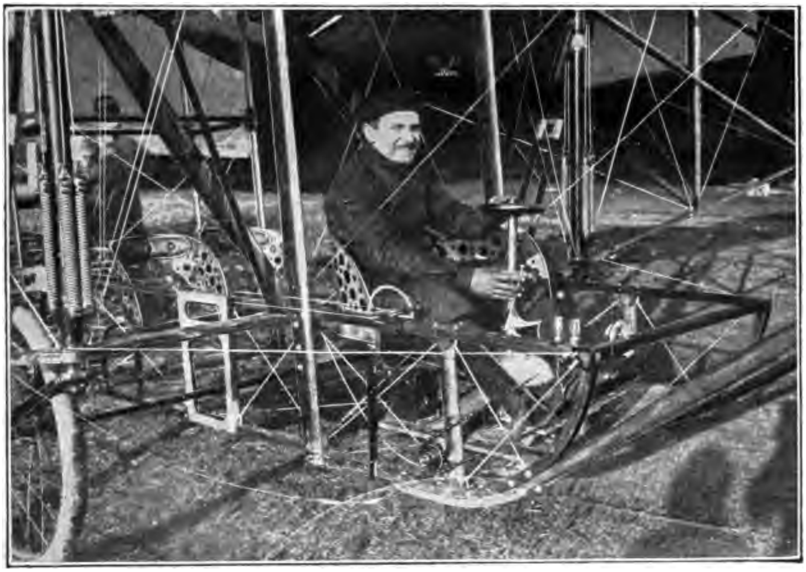


Fig. 14. Close View of Bleriot "Bus," Showing Seats for Passengers

at a speed of 55.9 miles an hour. The weight of the machine complete was 1,322.75 pounds, and the live load transported was the same, making the total load taken aloft 2,645.5 pounds, or more than 1¼ tons, this being the first flight on record in which the weight of the load has been equal to that of the machine itself. Despite this enormous load the aeroplane rose without any perceptible difficulty. The machine was a biplane of special design, built by Breguet himself.

Following this, Sommer carried seven people for 1 hour 31 minutes, Moineau took two people for a two-hour cross-country trip, while the two-man altitude record was put at 9,840 feet by Prevost, and the three-man distance record was jumped to 69 miles. Hirth took a passenger from Munich to Berlin, 330 miles, and Renaux carried a passenger with him the entire distance of the European circuit, a race of 1,073 miles. These are only the most prominent passenger-carrying flights, it being conservatively estimated that the French machines turned out during 1911 alone carried a total of 5,000 passengers during that year while probably a lesser number were carried in all the other countries put together.

At the Chicago Meet in August, 1911, Sopwith carried two people besides himself in a Wright biplane at 34.96 miles per hour, while at the same meet Parmalee carried 458 pounds weight. At the Nassau Meet, in September of the same year, Lieutenant Milling carried two passengers for nearly 2 hours.

Speed. Speed records kept pace during 1910 with those for duration, passenger carrying, and altitude, speeds in excess of 70 miles an hour having been attained, and it was then thought that any increase over this could be achieved only by radical departures in design. With the exception of the record for 2½ kilometers (1.5 miles), all records for that year of from 5 to 90 kilometers (3 to 55.8 miles) were made by Le Blanc in a Bleriot at one time—the Gordon-Bennett trophy race at Belmont Park. During 1911, his figures were left way behind in every one of the great European races. Vedrines made 93 miles an hour in a Morane monoplane, while during the Paris-Madrid race he flew at the rate of 135 miles an hour with a following gale. Weyman made an average of 78 miles an hour over a closed circuit in a Nieuport monoplane, winning the Gordon-Bennett trophy for America.

THE FLYING MACHINE OF THE FUTURE

Now that flying has become an accomplished fact, speculation as to just what the flying machine of the future will be like is quite as rife as it ever was when mankind generally regarded human flight as one of those long-cherished illusions, which, like perpetual motion, would endure to torment the inventive mind as long as the race existed. Wondrously impossible contrivances as large as the modern sky-scraping hotel are talked of and pictured, and the imagination is drawn upon to supply details that will probably never exist elsewhere. But the developments of the past few years have been so marvelous and so rapid that some even of what now appear to be wholly fanciful machines may actually be built in the future.

With all that has been accomplished in the past five years, it is evident that the first steps have scarcely been taken. The only thing that actually has been achieved is the establishment of the principles upon which human flight is based—those elusive laws of science that had been sought in vain for centuries previous. So far as the machines themselves are concerned, they can scarcely be said to have advanced very much. They still represent the same crude assemblage of wood, wire, and canvas that the Wright Brothers and their numerous predecessors were forced to adopt for their experiments, as they represented the only materials available. Before going into this phase of the matter at any length, however, it will be of interest to take up the question as to just what type of machine is likely to survive.

Unpromising Types. *Ornithopter.* It was only logical that first attempts at flight should be patterned after nature—many were of the opinion that if man were ever to fly he must imitate the birds. Strangely enough, some people are still of this opinion, but since flight based upon a scientific study of the laws governing sustentation in the air has become a reality, they are in the minority. Man's weight in proportion to the power he is able to exert is so puny in comparison with that of the birds, as to make any possibility of development along this line out of the question. Flying with power-driven wings is likewise extremely problematical, as will be apparent when the weight that must be sustained in the air is taken into consideration. The mechanism necessary to cause huge wings to beat in imitation of the bird would not only be weighty and complicated but likewise extremely inefficient, as compared with the propeller-driven soaring plane, which in itself has a great deal of room for improvement. Yet the hope of eventually being able to fly with an "ornithopter," as this type of machine is termed, is not yet dead. A Californian, H. La V. Twining, has carried out an unusually promising series of experiments on a small scale, employing man power exerted through the medium of bicycle pedals and gearing. It is very much to be feared, however, that like the hot-air engine and numerous other inventions that appeared to promise great results from the success achieved with a small model, the ornithopter would be about as cumbersome and hopeless as its name, when attempted on a scale large enough to be of any practical use.

Helicopter. Just as there is a certain class that still looks to the ultimate development of the ornithopter, so is there likewise another class which does not appear to be influenced to any great extent by the fact that flight is an *established* fact. This latter class pins its faith to the *helicopter*—which affords a still further example of how misleading may be the results obtained with a small model, as related by the Wright Brothers in their experience with toy helicopters. A helicopter consists essentially of a motor and a propeller, the propeller being designed to rotate in a horizontal plane and to carry the machine and the aviator aloft by reason of its downward thrust. This is the simplest type of helicopter, next to the toy of the same name, but there are other types which differ only in the elaboration of their detail, or in their combinations with other elements, such as planes, which tend to obscure their true character. Usually, two propellers have been employed, designed to turn in opposite directions, in order that the tendency of one to rotate the whole machine with it could be offset by the other. The fallacy of the helicopter seems very self-evident, and yet large sums of money and no little inventive effort have been expended in attempting to evolve something practical out of the principle of sustentation by means of the thrust of a horizontal propeller. If the object of a flying machine were merely to shoot straight up into the air from the ground like a rocket, it might be worth something to be able to start into the air without the necessity of running along the ground, which is the chief advantage claimed by its advocates, though but one helicopter has

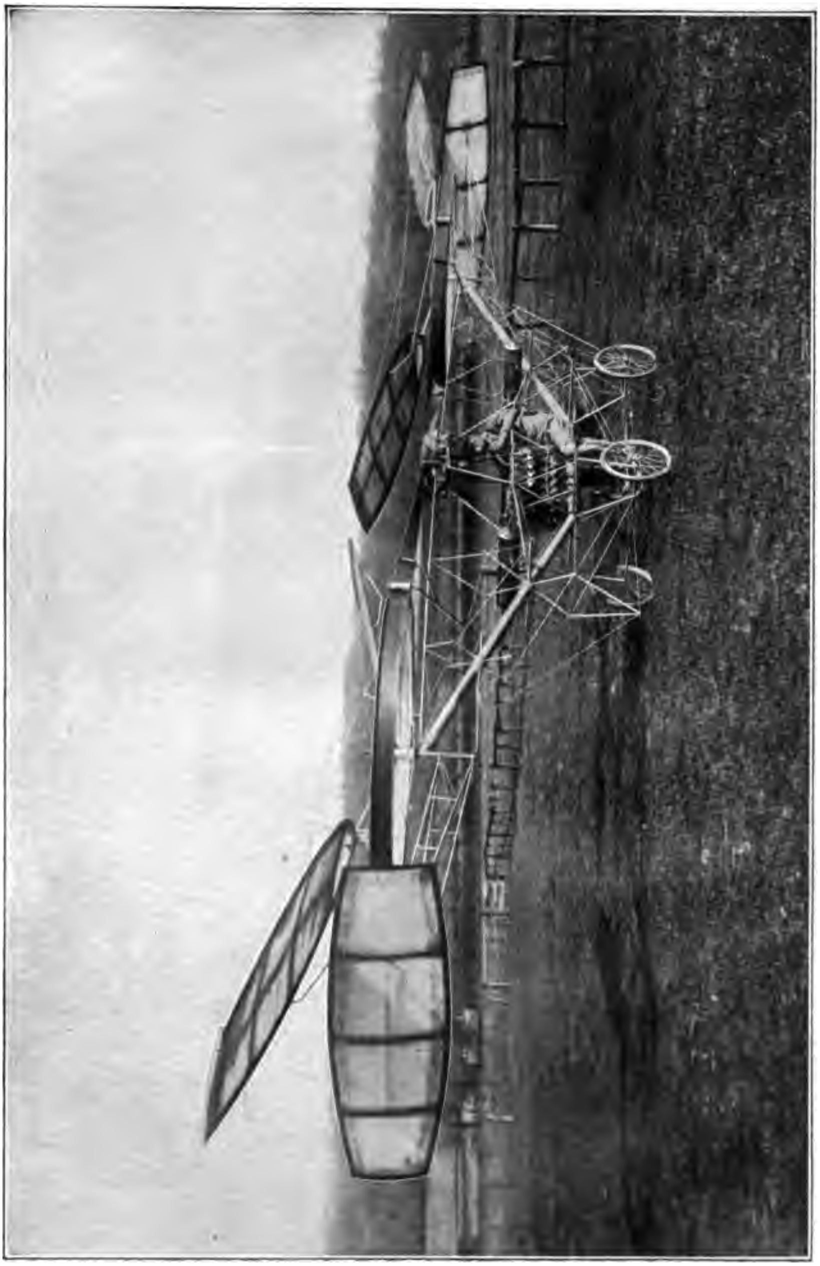


Fig. 15. Cornu Helicopter, Probably the Only Machine of This Type Which Has Been off the Ground

ever done so with an aviator. But the single reason for the existence of the aeroplane is the same as that of the locomotive, the steamship, the automobile, the bicycle, and the wagon—transportation—and the ability to ascend straight up into the air does not bring with it any capacity for traveling in a horizontal plane.

In addition to being unable to move except in a vertical plane, the helicopter likewise has the somewhat serious disadvantage of being totally without any supporting surface in case of failure of the motive power, and even with the highly developed internal combustion motor of the present day, it would indeed be a foolhardy aviator who would risk his life in a machine in which the failure of the power for even a moment meant certain death. Paul Cornu, a Frenchman, developed this type far beyond any of his contemporaries, Fig. 15, and he is said to have actually succeeded in getting off the ground, thus showing an advance in that highly important particular over other helicopter machines so far built. This machine is likewise an improvement in design, as the propellers are so mounted that they

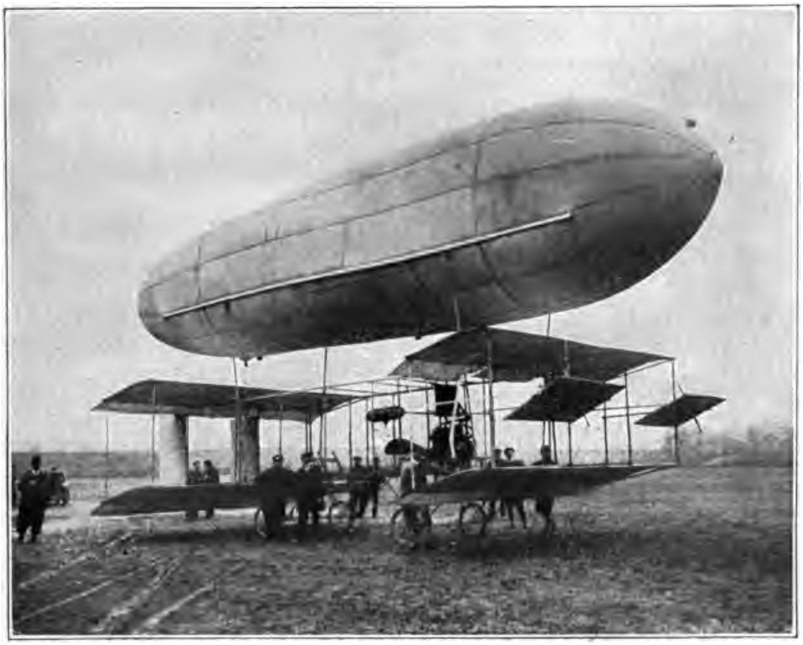


Fig. 15. Combination Dirigible and Aeroplane

can be turned at an angle, as was the case with Wellman's dirigible, the idea being that once in the air at the desired height, the thrust of the propellers, or at least one of them, could be exerted in a horizontal direction, while the other served as a support, thus providing for horizontal travel. Coming down from a height of 9,000 feet with a dead motor, as has been done in an aeroplane, would be a brief and exciting experience in a Cornu helicopter. Another attempt to provide a means of horizontal travel took the form of inclined planes. These were not intended in any way for support, but merely to send the machine ahead by reason of the reaction of the thrust of the horizontal propellers upon them. At the present writing, it seems highly improbable that anything practical will ever be done with either the ornithopter or the helicopter.

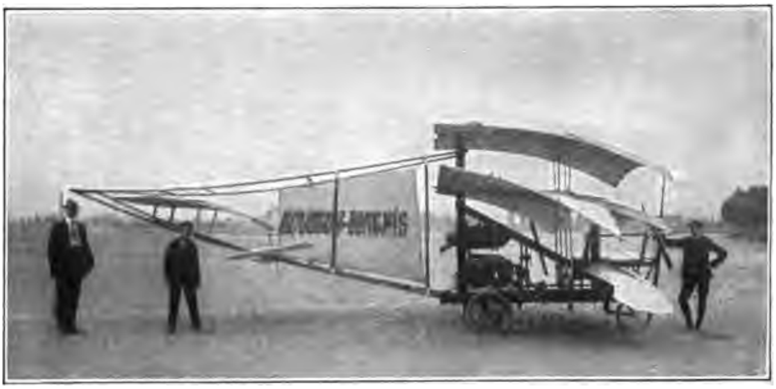


Fig. 17. Freak Type of Biplane Which Has Actualy Flown

Miscellaneous. Apart from the types mentioned, there are hundreds that could not be classified except as freaks, the majority of which are not worth even passing mention. One of these, the chief merit of which appears to be its novelty, is illustrated in Fig. 16. This is a combination dirigible balloon and aeroplane, though just what is to be gained in evolving such a hybrid is difficult to explain. It is neither one nor the other and has the disadvantages of both without the merits of either. The gas bag is not of sufficient size to effectually support any weight while, on the other hand, it is so large as to prove practically an anchor for the aeroplane, which could make but a very slow speed with such an encumbrance.

Another freak type, one of the few such machines that had really flown, is shown in Fig. 17.

Monoplane vs. Biplane. Whether the ultimate flying machine will be of a type radically different from those with which we are now familiar, or purely a development of the present types, is a question that can scarcely be answered satisfactorily. Any attempt to do so would be merely a delving into the realms of speculation, and those most thoroughly versed in the art as developed up to the present day are most reluctant to venture an opinion. As in other fields, it is usually the man who knows least about the subject who is anxious to prophesy a revolution in design. But leaving out of consideration altogether the question of the development of some entirely new type—at least new as compared with the machines at present in use, such as the ornithopter and the helicopter—there is a great deal of difference of opinion between aviators and builders as to whether the *monoplane* or the *biplane* will eventually reign supreme.

The advocates of both are equally enthusiastic and equally positive that the particular machine they favor is the only practical type. Even in their present stage of development both have exhibited marked characteristics and peculiarities of their own. The biplane has great stability and ease of maneuvering in the hands of a skilled pilot, while the monoplane has carried away all records for speed. With the materials at present employed, the biplane is an easier machine to construct and can likewise be made safer so far as its structure is concerned. It is also an excellent weight carrier, though the development of the Bleriot "bus" which has a capacity of eight passengers, shows that the monoplane is not at all lacking in this respect. Neither the disadvantages nor the advantages all lie with either type—both have numerous merits, and where the question of speed is paramount, the superiority of the monoplane must be conceded. When a comparison of the good and bad points of the two is made, it seems evident that both will always have numerous advocates and staunch supporters, and that unless something radically new in the design of one makes it immeasurably superior to the other, both will continue to develop contemporaneously.

Improvements in Construction. From an engineering point of view there can be no question but that the greatest room for improvement at present exists in the construction. When inventors were struggling with the problem of flight, and even for the first few years after the principles which made it possible, were definitely established, there was every reason why the cheapest and easiest materials to obtain should be employed; likewise for their assembly in the simplest and most expedient manner. Financial limitations, if no other, made this imperative. But now that that day has passed and aeroplane building companies, or at least those marketing the well-known standard types, are possessed of ample capital and facilities, while special materials are at hand for the purpose, there appears to be no reason why the present-day crude assemblage of *canvas, wire,* and *sticks,* which compose the average biplane or monoplane, should continue to survive longer. Lightness is absolutely essential, but it can be obtained with materials which have greater strength and durability and which may be assembled with greater security than is the case at present, viz, steel and aluminum, the latter term naturally including the numerous aluminum alloys marketed under different names. Hardness and tensile strength have been developed to such a degree with aluminum and magnesium alloys, still preserving their extreme lightness, that there is no longer any reason for the continued use of either wood or canvas. These alloys are naturally far more expensive, while the use of any metal not only involves greater manufacturing cost but also more difficulty in construction at the outset. Nevertheless, it is safe to say that the machine of the future will be built entirely of metal.

A step in this direction is to be seen in Paulhan's new all-steel machine, illustrated in Figs. 18 and 19. In this, both wood and cloth have been dispensed with entirely. The planes, as well as the struts, braces, and the like are all of steel, and the greater security of fastening which this affords makes it possible to eliminate many of the otherwise indispensable guys, which, while of small cross-section in themselves, create considerable resistance. That the use of steel in this connection means weight saving is evident from the fact that this machine tips the scales at only 770 pounds, although it has a spread of 33.5 feet. Its efficiency is obvious from its comparatively small supporting surface of 470 square feet. The power plant consists of a 50-horse-power revolving Gnome motor, so that the machine carries 9.4 pounds per square foot of area, which is an unusually good showing. The aviator's seat and protecting car containing all the controls is placed between the main planes, which marks a radical departure from the customary plan of placing them on the lower plane frame.

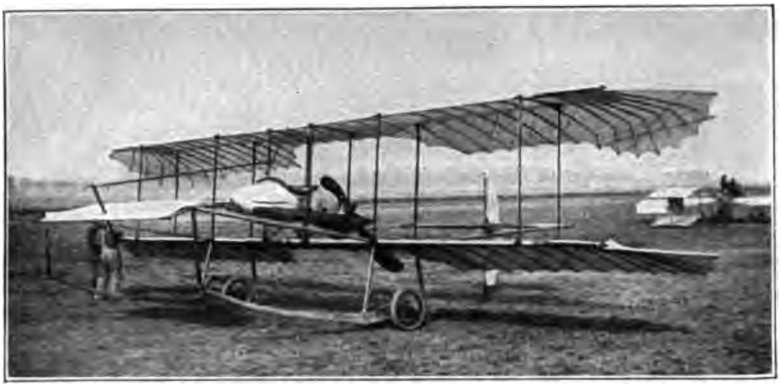


Fig. 18. Paulhan's All-Steel Biplane

This construction would hardly be permissible upon the usual wood-frame biplane, as the struts to support the aviator's weight would

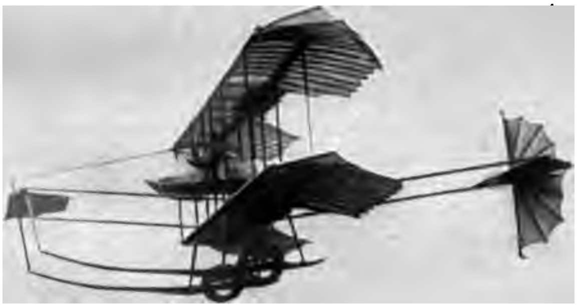


Fig. 19. Paulhan's All-Steel Biplane in Flight

have to be very much heavier than usual, while the necessary bracing to hold the seat rigid would also involve weight to an almost prohibitive extent.

That aviators generally have had in mind the employment of metal for construction is evident from numerous instances. John D. Moissant, who was the first to fly from Paris to London and whose skill and daring gained him many admirers, completed several months before his death at New Orleans, in December, 1910, the design of a monoplane to be built entirely of aluminum. Such a machine was constructed and undoubtedly would have been successfully developed, had its inventor lived. Quite a number of others have since built machines either partly or entirely of metal and the strong tendency toward its use was very marked in the machines exhibited at the Paris Salon, December, 1911. Damage to a metal framed and winged aeroplane is naturally much more difficult and expensive to repair so that the use of steel and aluminum can hardly become general until the experimental stage is left behind. The necessity for warping the wings in accordance with the principles laid down by the Wright Brothers, a device which is now almost universally employed, presents no particular difficulties of construction in connection with the use of a metal supporting surface.

Racing Machine of the Future. As the result of a study of recent developments, J. Bernard Walker has outlined in the *Scientific American,* the plan of the racing machine of the future, as follows:

> The future high-speed flyer will possess the same tapering, rounded body and the narrow, wide-spread wings which characterize the swiftest of birds—the albatross. Langley showed that the leading portion of the plane is most efficient because it is constantly moving on to fresh, undisturbed bodies of air. As the after portion of the plane has to work upon air which has already received a downward velocity, this air is unable to exert the effective reaction provided by air that is inert. Hence, a plane 5 feet wide by 10 feet long becomes more efficient when divided longitudinally, making it 2½ feet wide by 20 feet long. The wings will accordingly be long and narrow, and when made of metal, it will be possible to give them the sweeping, rounded forms, which prevent eddy making. The body will be of a generally circular or oval section and, to allow of a long and gradual taper for ease in traversing the air, will have considerable length, this adding greatly to the fore-and-aft stability in flight.*
>
> The present wood, canvas, and wire construction will have to go. It is a makeshift at the best and was adopted because, in the early days of experiment, it offered a cheap and light combination of material, and one which, in the event of the inevitable breakages, could be cheaply and quickly repaired. Its place will be taken by some of the many remarkable alloys of steel now

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*Several bodies of this type were shown on some of the French machines at the Paris Salon, December 1911.—Ed.

available—metals of enormous strength and toughness in proportion to their weight. The use of these coupled with careful designing by the skilled engineer, will make it possible to produce an aeroplane of much greater strength that will weigh no more than the present machine, and will present far less resistance.

The principal resistances encountered by an aeroplane are those due to the lift and the head surface. That due to the lift is fairly constant, for as the speed increases, the angle of incidence decreases, and there is always an adjustment between the two which provides sufficient vertical reaction at all times to lift the weight of 500 to 1,000 pounds, as the case may be. The head resistance, however, increases approximately as the square of the speed, and if it be 100 pounds, say at 40 miles an hour, it will rise to 400 pounds at 80 miles an hour. Hence, in a racing machine, the great importance of reducing the head surface to the least possible limit consistent with structural requirements. It is this consideration of head resistance which has doomed the biplane as a purely racing type. When Octave Chanute built the first biplane glider, with its light but very rigid Pratt trussing of vertical wood struts and diagonal wire tires, he produced an excellent piece of engineering construction, which has proved to be ideally adapted to the early experimental stage which is now drawing to its close. But for high-speed results, because of the large amount of head surface presented, the Pratt truss was doomed to ultimate extinction. Unquestionably, the higher speed attained by the monoplane is due largely to the fact that its trussing is simpler, and the head surface, particularly of the wire stays, is relatively much less. The great amount of resistance offered by the apparently negligible surface of the thin wires was shown by Langley's experiments to be due to the fact that the rate of vibration of the wire under the rush of air is so great that it practically presents a solid surface, the width of which is equal to the amplitude of vibration. Hence, a tightly-strung wire offers an amount of resistance which is seemingly out of all proportion to its actual surface.

It follows, then, that even the simple king-pin trussing of the Bleriot and Antoinette types must go if we are to achieve the highest speed which is predicted for the future racing machine. This will be possible only if some high-grade sheet metal is substituted for the canvas of the wing surface, and the necessary transverse bending strength is secured by means of plate-steel members enclosed within the wing surfaces and strongly riveted to the structure of the main body of the machine. Turning to nature for guidance again, we find that the fast-flying birds fold their legs snugly beneath them when in flight. The racing aeroplane must do the same.

Mr. Walker goes on at some length detailing the construction of such a machine, as well as of a special folding chassis, operated by compressed-air cylinders, which would act to cushion the shock of landing. He also purposes to operate the movable wing tips by similar power, a two-way valve to the cylinders being controlled by a gyroscope, which may be rendered inoperative when it is desired to make a turn. After it has been sufficiently developed by experimental work, he thinks it conservative to expect a speed of 100 to

125 miles. As nearly 80 miles per hour has already been attained with the present construction, this estimate does not appear to be overdrawn.*

Reefed Supporting Surfaces. Another feature that is likely to become a subject of attention shortly and which will undoubtedly have considerable influence on the development of the machine of the future, is that of a variable supporting area; in other words, a method of "reefing" the supporting surface to adapt its area to the speed of the machine. Aeroplane speeds have already reached a point where this is to the fore. The demand for a variable surface is based upon one of the most important of the laws of flight, viz, that the area of the necessary supporting surface of an aeroplane varies inversely as the square of the velocity. This principle, affirmed by Langley and embodied in his great work "Experiments in Aerodynamics," has been disputed by some European theorists and practical aeroplane builders, but the experience of the past two years appears to verify it. If the law holds good, the standard Wright biplane of 1910, which, with about 500 square feet of surface, has a speed of 40 miles an hour, at 60 miles would need only 222 square feet for support, and at 100 miles, only 80 square feet.

That the principle is generally correct, or, at least, that its application does not produce too great a reduction of surface, is shown by the racing machines exhibited and flown by the Wright Brothers at the International Meet in the autumn of 1910. One of these, a semi-racer with a speed of 60 miles an hour, was provided with only 150 square feet of supporting surface. The standard Wright machine, driven at 60 miles an hour, would need, according to this law, 222 square feet. Its weight, however, with the aviator and full fuel and water supply, is 1,075 pounds, whereas the semi-racer weighs with pilot and fuel only 760 pounds. The difference in weight would account largely for the reduction of the area from 222 to 150 square feet of sustaining surface. Further verification is found in the Bleriot racer, which, with slightly less speed, and a weight of about 650 pounds, including the aviator, also has less than 150 square feet of sustaining surface. It is significant that in their actual racing machine, which is 15 miles an hour faster, the Wrights did not attempt to reduce the supporting surface any further, both the semiracer and the racer having 150 square feet of surface. The racer, however, is heavier, weighing about 900 pounds ready to fly.

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*The internally braced wing came into existence in the Antoinette armored monoplane (see Special Types) in 1911, and the 100-mile an hour mark was reached in February, 1912 (see Aviation Records).

If, then, the high-speed flyers endorse Langley's law, it follows that there will be a further reduction of area in the racing machines of the future. If the standard Wright machine with 500 square feet of surface could be driven at 100 miles an hour, it would need only 80 square feet of surface for support, and if a speed greater than 100 miles per hour were accomplished, the sustaining surface would come down to a pair of long, narrow blades, approximating in form the wings of the swift or the swallow. But it must be remembered that these reduced surfaces are equal to their work only if the machine is being driven at its highest or, at least, at a high velocity; and they are, therefore, theoretically too small to lift the machine from the ground or allow it to return safely at the lowest speeds which are necessary in starting and alighting. Proof of this was shown in the accident which disabled the Wright racing machine in the contest for the international trophy at Belmont Park, when the stopping of the motor and the sudden slowing down of the biplane caused it to drop so swiftly to the ground that its momentum partially wrecked the machine and threw the aviator from his seat. Probably, having been accustomed to the larger surface Wright machine, he did not realize the necessity of descending with the main planes at a large angle of incidence in order to check the velocity. In any case it is evident that if the racing aeroplane reaches a speed of 100 miles an hour, it will be necessary for safe control to provide it with some means of enlarging or reducing the supporting area proportionately to the speed, or of altering the angle of incidence of the wings to generate increased resistance for alighting safely.

This problem should not be particularly difficult of solution. The additional surface could be arranged to be drawn under or within the main surfaces either from the ends or from the rear. If, as seems quite likely, the aeroplanes of the future be built entirely of metal, the problem will be much easier to work out. A large percentage of the accidents to existing machines are due to descending and landing at too great an angle or at too great a speed. Were it possible voluntarily to increase the surface at the time of making a landing, the risk of accident from this cause would be greatly reduced.

Duplicate Power Plant. Another trend of development that is receiving considerable attention is the design of an aeroplane provided with two motors, either one of which may be employed to drive the propeller or propellers, in order to avoid the necessity of alighting should the motor stop, as is the case with present machines. Such a contingency involves no great danger when flying over an aviation field, but in cross-country flights the matter of finding a suitable place to alight in an emergency is something that the aviator prefers not to have to decide. Edwin Gould has offered a prize of $15,000 for a successful machine of this type, which will be competed for through the *Scientific American.*

In the foregoing, no attempt has been made to point out all the possibilities of the future machine. So much has been accomplished in such a marvelously short period and so much will undoubtedly be brought about in the next few years, that it would be idle to do more than bring to notice a few of the salient features which most likely will receive the greatest share of attention in the near future.

EXAMINATION PAPER.